Proceedings of

5th INTERNATIONAL MECHATRONIC STUDENT micro-CONFERENCE

Óbuda University, Donát Bánki Faculty of Mechanical and Safety Engineering,

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In cooperation with:

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FOREWORD

The ***International Mechatronic Student micro-Conference 2017*** has been successfully held on **19th of December 2017** (now the 5**th** time**)**, at the **Donát Bánki, Faculty of Mechanical and Safety Engineering, Department of Mechatronics,** of the **Óbuda University**.

The aim of conference is to provide opportunity to the students, for **Hungarians** as well as **students from abroad (e.g. Erasmus, Stipendium Hungaricum),** which are active in field of mechatronic sciences, to networking; deepen their professional knowledge, presentational skills and proficiency in English communication.

This conference series has been started in year 2012. In this year, the conference papers were **reviewed** and based on acceptance the authors received the invitations. All the accepted papers had to be presented orally. The accepted and presented papers are accumulated in this **Conference Proceeding**, what is **published electronically** on the conference Website. I trust also that this student-conference will be an impetus to stimulate further study and research in mechatronics. Enjoy the reading.

link: *http://old.bgk.uni-obuda.hu/mei/IMSmC/2017/committees.html*

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Conference Founding Chair

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Abstract

In recent years it has become apparent that fiber-optics are steadily replacing copper wire as an appropriate means of communication signal transmission. They span the long distances between local phone systems as well as providing the backbone for many network systems. Other system users include cable television services, university campuses, office buildings, industrial plants, and electric utility companies.

A fiber-optic system is similar to the copper wire system that fiber-optics is replacing. The difference is that fiber-optics use light pulses to transmit information down fiber lines instead of using electronic pulses to transmit information down copper lines. Looking at the components in a fiber-optic chain will give a better understanding of how the system works in conjunction with wire based systems.

Keywords: cables, fiber optics ,internet

1. Advantages of fiber optic cables.

1.1. Immunity to Electromagnetic Interference

Although fiber optics can solve data communications problems, they are not needed everywhere. Most computer data goes over ordinary wires. Most data is sent over short distances at low speed. In ordinary environments, it is not practical to use fiber optics to transmit data between personal computers and printers as it's too costly. Electromagnetic Interference is a common type of noise that originates with one of the basic properties of electromagnetism. Magnetic field lines generate an electrical current as they cut across conductors. The flow of electrons in a conductor generates a magnetic field that changes with the current flow. Electromagnetic Interference does occur in coaxial cables, since current does cut across the conductor. Fiber optics are immune to this EMI since signals are transmitted as light instead of current. Thus, they can carry signals through places where EMI would block transmission.

1.2 Data Security

Magnetic fields and current induction work in two ways. They don't just generate noise in signal carrying conductors; they also let the information on the conductor to be leaked out. Fluctuations in the induced magnetic field outside a conductor carry the same information as the current passing through the conductor. Shielding the wire, as in coaxial cables can reduce the problem, but sometimes shielding can allow enough signal leak to allow tapping, which is exactly what we wouldn't want.

There are no radiated magnetic fields around optical fibers; the electromagnetic fields are confined within the fiber. That makes it impossible to tap the signal being transmitted through a fiber without cutting into the fiber. Since fiber optics do not radiate electromagnetic energy.

1.3 Non Conductive Cables.

Metal cables can encounter other signal transmission problems because of subtle variations in electrical potential. Electronic designers assume that ground is a uniform potential. That is reasonable if ground is a single metal chassis, and it's not too bad if ground is a good conductor that extends through a small building. However, the nominal ground potential can differ by several volts if cables run between different buildings or sometimes even different parts of the same building.

Signal levels in semiconductor circuits are just a few volts, creating a problem known as ground loop. When the difference in ground potential at two ends of a wire gets comparable to the signal level, stray currents begin to cause noise. If the differences grow large enough, they can even damage components. Electric utilities have the biggest problems because their switching stations and power plants may have large potential differences.

A serious concern with outdoor cables in certain computer networks is that they can be hit by lightning, causing destruction to wires and other cables that are involved in the network. Certain computer companies are aware of this problem and trying to solve it by having protective devices for wire circuits to block current and voltage surges.

Any conductive cables can carry power surges or ground loops. Fiber optic cables can be made non-conductive by avoiding metal in their design. These kinds of cables are economical and standard for many indoor applications. Outdoor versions are more expensive since they require special strength members, but they can still be valuable in eliminating ground loops and protecting electronic equipment from surge damage.

1.4 Eliminating Spark Hazards

In some cases, transmitting signals electrically can be extremely dangerous. Most electric potentials create small sparks. The sparks ordinarily pose no danger, but can be really bad in a chemical plant or oil refinery where the air is contaminated with potentially explosive vapours. One tiny spark can create a big explosion. potential spark hazards seriously hinder data and communication in such facilities. Fiber optic cables do not produce sparks since they do not carry current.

1.5 Ease Of Installation

Increasing transmission capacity of wire cables generally makes them thicker and more rigid. Such thick cables can be difficult to install in existing buildings where they must go through walls and cable ducts. Fiber cables are easier to install since they are smaller and more flexible. They can also run along the same routes as electric cables without picking up excessive noise.

One way to simplify installation in existing buildings is to run cables through ventilation ducts. However, fire codes require that such plenum cables be made of costly fire retardant materials that emit little smoke. The advantage of fiber types is that they are smaller and hence require less of the costly fire retardant materials. The small size, lightweight and flexibility of fiber optic cables also make them easier to be used in temporary or portable installations.

1.6 High Bandwidth Over Long Distances

Fiber optics have a large capacity to carry high speed signals over longer distances without repeaters than other types of cables. The information carrying capacity increases with frequency. This however, doesn't mean that optical fiber has infinit bandwidth, but it's certainly greater than coaxial cables. Generally, coaxial cables have a bandwidth parameter of a few MHz/km, where else the fiber optic cable has a bandwidth of 400MHz/km. *(These figures are just approximations and do vary from cable to cable!)* This is an important factor that leads to the choice of fiber for data communications. Fiber can be added to a wire network so it can reach terminals outside its normal range. Emissions cannot be intercepted and physically tapping the fiber takes great skill to do undetected. Thus, the fiber is the most secure medium available for carrying sensitive data

2.1 System Reconfiguration

Although fiber optics are renowned for their efficiencies and loads of advantages, there are a few drawbacks in them and one of them is system reconfiguration. Converting existing hardware and software for the use of fiber optics does take a lot of time and money which also reduces the turnover for any profit making firm in the market. Sometimes it may be more convenient to transmit high speed computer data serially (one bit after another) than sending several bits at a time in parallel over separate wires. This changeover requires modification in both hardware and software. Minor differences can cause old programs to crash and make data in old files unreadable. Even though the need for such modifications can be reduced by designing fiber optic systems with interfaces that look just like electric ones, it would not make most efficient use of fiber transmission capacity and would increase costs.

2.2 Limitations in Local Area Networks

In Local Area Networks, fiber optics is not used as widely as one would expect. One reason is the implementation requires great deal of changes in current networks and systems. This requires a lot of time and effort which the management is not willing to sacrifice. People are comfortable with what they have and don't want to change. Although most problems regarding program changing can be solved, the solutions to it will take much longer than expected. Thus, any new program has to be a big improvement over the old one to justify a significant change (although the great improvement usually means that the old program does not work).

Another fundamental problem in fiber optic LANs is the change in technology. The hardware and software to make LAN run efficiently add up to an expensive package. If many terminals in a building must be in constant touch with each other and a variety of other hardware, such as printers and storage devices, LAN will be cost efficient. However, if the real need is to keep the terminals in touch with a mainframe computer, it would be cheaper to run cables between them and the mainframe. If the terminals need to talk to each other, ordinary telephone lines could very well be used as telephone lines are much cheaper than fiber optics.

2.3 Economic Evaluation

The major practical problem with fiber optics is that it usually costs more than ordinary wires. All costs elements involved in economic evaluation can be grouped into two main classes; which are investment costs and operation costs. The investment costs usually includes expenditures related to acquiring and owning properties and plants, in this case changing wires to fiber optic cables. All investment costs should be considered, such as those incurred for equipment and materials (also including storage and handling costs), engineering costs and miscellaneous costs. Operation costs include the usage of fiber optics and the wear and tear of it. The higher costs of fiber is often not by itself. Fiber optic cables are much cheaper than coaxial cables. The main difference comes when all the other components of fiber optics add up, such as transmitters, receivers, couplers and connectors. Fiber systems require separate transmitters and receivers because they cannot directly use the electrical output of computer devices; that signal must be converted into optical form and then converted back into electrical form. Fiber optic connectors and couplers are more expensive than any other electrical components. These costs are the ones that add up and form the major disadvantage of fiber optics.

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International Mechatronic Student Micro-Conference

Bánki Donát Faculty of Mechanical &Safety Engineering
Institute of Mechatronics & Vehicle Engineering,
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GEOMETRIC DETERMINATION OF INVERSE KINEMATIC OF PARALLEL ROBOTS

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Abstract

Goal of my presentation is the geometric determination of inverse kinematic of parallel robots. In this context, I have solved the inverse kinematic to general parallel robots by geometric way. During my work, I wrote a program in Matlab which can specify the inverse kinematic considering the parameters of robots, as well as it can design a time optimum travel path to the robot and it can export the calculated data to an Excel file.

Keywords: parallel robots, time optimum travel path, geometric determination of inverse kinematic.

1. Introduction

1.1. Robots

Important terms in this topic:

The International Organization for Standardization gives a definition of a manipulating industrial robot in ISO 8373:
"an automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications." [1]

The determination of the International Federation of Robotics about the service robots is:
"A service robot is a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations." [3]

End effector is the device at end of the robot arm which is designed for the robot to interact workpiece.

Working point is the point of the end effector where the robot makes interact to the environment.

Working space of the robot is the space where the points can be reached by working point of the robot

The position of rigid bodies can be described by 6 component, which are 3 prismatic and 3 revolute. These are called **degrees of freedom** (dof).

The robot as a mechanism is consists of links, which are connect by joints. The joints have:

one dof	revolute joint prismatic joint
two dof	universal joint
three dof	spherical joint

A kinematic chains can be:

opened when the kinematic chain first and last link is different.

closed when the kinematic chain first and last ink is same. (belong here the kinematic chains of parallel robots)

1.2. Delta Robot

The delta robot was invented in 1980s by Reymond Clavel who published [6]. Goal of his invent was a robot which can move fast small and light parts.

“The device comprises a base element (1) and a movable element (8). Three control arms (4) are rigidly mounted at their first extremity (15) on three shafts (2) which may be rotated. The three assemblies each formed by a shaft (2) and an arm (4) are the movable parts of three actuators (13) of which the fixed parts (3) are integral with the base element. The other extremity (16) of each control arm is made integral with the movable element through two linking bars (5a, 5b) hingedly mounted on the one hand to the second extremity (16) of the control arm and, on the other hand, to the movable element. The inclination and the orientation in space of the movable element remain unchanged, whatever the motions of the three control arms may be. The movable element supports a working element (9) of which the rotation is controlled by a fixed motor (11) situated on the base element. A telescopic arm (14) connects the motor to the working element.” [5]

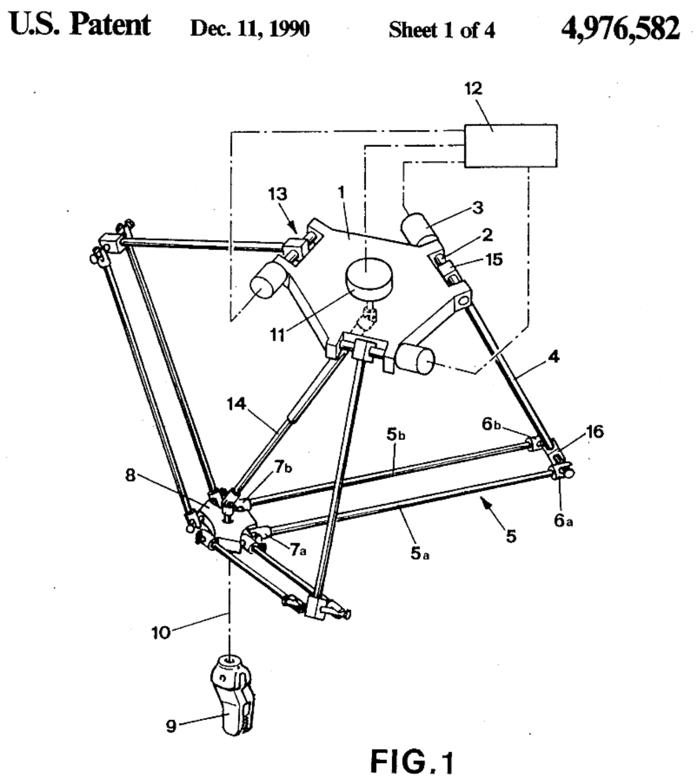

Fig.1. *Construction of delta robot [5]*

2. Invers kinematic transformation geometric determination

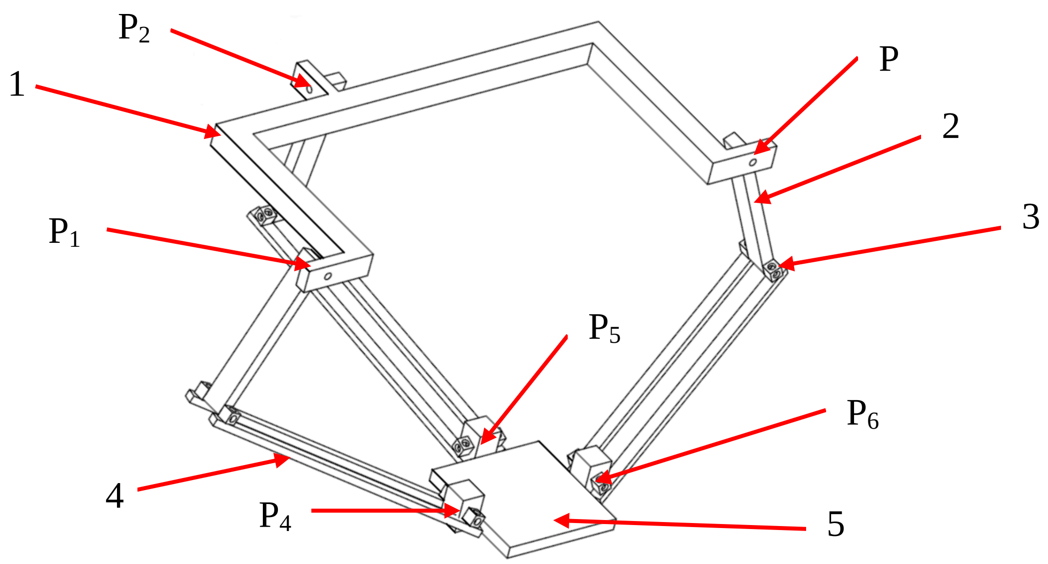

Fig.2. *Structure of General triangular parallel (Somlo) robot special (expressly perfect for stepping) special case and remarkable points*

1. Base triangle
2. Control arms
3. Joints points
4. Linking bars
5. Movable element

The P_1, P_2, P_3 the points where the actuators connect to the base triangle and to the control arms. The P_4, P_5, P_6 the points where the linking bars connect to the movable element.

The next part I summarized the invers kinematic solution. (Details in my thesis [2])

Given:

Working point: $M = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$

Rotation points of actuators: $P_1 = \begin{bmatrix} U_1 \\ V_1 \\ T_1 \end{bmatrix}$; $P_2 = \begin{bmatrix} U_2 \\ V_2 \\ T_2 \end{bmatrix}$; $P_3 = \begin{bmatrix} U_3 \\ V_3 \\ T_3 \end{bmatrix}$

Rotation plains of actuators: $\underline{n_1} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = j$; $\underline{n_2} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = i$; $\underline{n_1} = \underline{n_3}$

Offset vector which show the position of the linking bars connection to the movable element from the working point: $\underline{e_4} = \begin{bmatrix} x_4 \\ y_4 \\ z_4 \end{bmatrix}$; $\underline{e_5} = \begin{bmatrix} x_5 \\ y_5 \\ z_5 \end{bmatrix}$; $\underline{e_6} = \begin{bmatrix} x_6 \\ y_6 \\ z_6 \end{bmatrix}$

Length of the control arms: r_1

Length of the linking bars: r_2

The rotation points of liking bars can specify by the offset vector and the working point. The next step is we must prescribe the sphere equations to the P_4, P_5, P_6 points, after that we cat these sphere by the rotation plains of the actuators. At we got 2 circle pairs, one of the pairs centres are P_1, P_2, P_3 points, the other centres are the P_4, P_5, P_6 points. The common point of circle pairs has 3 cases: first is when it does not have common point in this case the working point is not in the working space, second is when it has one common point, third is when it has two common point, in this case we must excluded one point. I excluded that point whose z coordinate is smaller because top of the robot, there are the actuators, and the control system of the actuators etc.

3. Time optimum travel path

The problem was in this section I had to write a program in Matlab which can unseal to points a general path and solve the invers kinematic for all points and from this data specify the data (optimal speed of the working point, maximum speed of the actuators etc.) of the time optimal travel path. In my program, the path can be determined by functions of the x, y, z axis.

In this case I used these data for the robot and for the path:

Rotation points of actuators: $P_1 = \begin{bmatrix} 50 \\ 0 \\ 0 \end{bmatrix}$; $P_2 = \begin{bmatrix} 0 \\ 50 \\ 0 \end{bmatrix}$; $P_3 = \begin{bmatrix} -50 \\ 0 \\ 0 \end{bmatrix}$

Offset vectors: $\underline{e_4} = \begin{bmatrix} 5 \\ 0 \\ 0 \end{bmatrix}$; $\underline{e_5} = \begin{bmatrix} 0 \\ 5 \\ 0 \end{bmatrix}$; $\underline{e_6} = \begin{bmatrix} -5 \\ 0 \\ 0 \end{bmatrix}$

Length of the control arms: 35

Length of the linking bars: 35

q_1=0,5 q_2=1 q_3=1,5

The functions describe the coordinate of the path is

$f(x) = 10 * \cos(rad)$ $f(y) = 10 * \sin(rad)$ $f(z) = 10 * \sin(2 * rad) + 10$

where read rad ∈ [0,2π] the step distance is 0,05.

After that, the parameters of path must be determined by the János Somló's method [4]. It is a point to point (ptp) path design.

The first step is the angel of the actuators mast be calculated all point of the path.

The second is we must specify the change of the angel of the actuators and the distance between two points then we can determine the maximum speed of the actuators from that data by this formula $\frac{q_{i\,max}*\Delta}{\Delta\delta}$ where is Δ is the distance between two points, Δδ is the change of the angel of the actuators. From this formula give the three-maximum speed of the Working point for the actuator, and the optimal speed is the smallest from these. From that data, we specify the speed of the actuators by this formula $\frac{\Delta\delta * v_{opt}}{\Delta}$. Next, we calculate the time of the sub-sections by this formula $\frac{\Delta}{V_{opt}}$, and sum of this times give the time of the path.

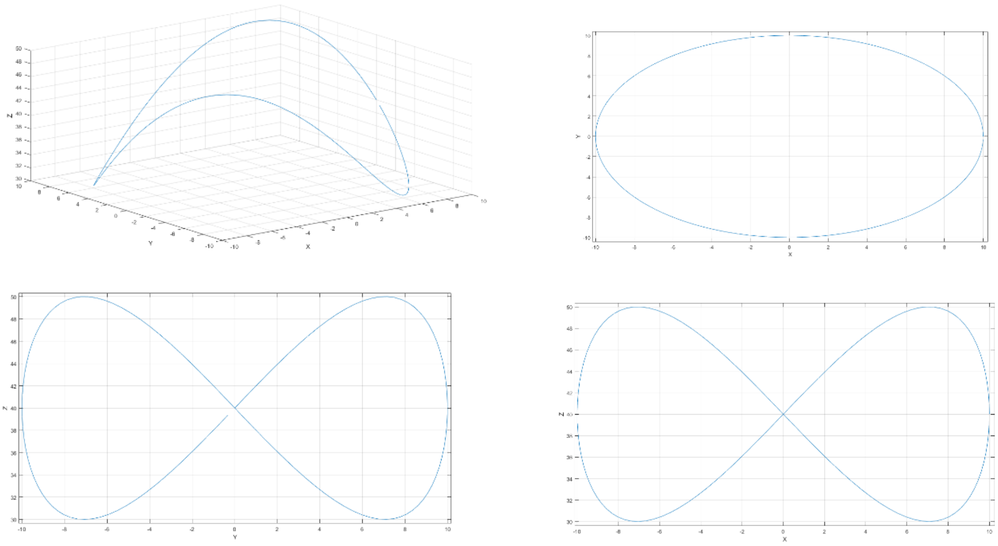

Fig.3. *The path of the working point*

The Matlab has advantages. it can the show the path of the working point and its projections (Fig.3.), and the Matlab can make useful charts for example: speeds of the actuators (Fig.5.) and angles of the actuators (Fig.4.), which is perfect for control the operation of robot.

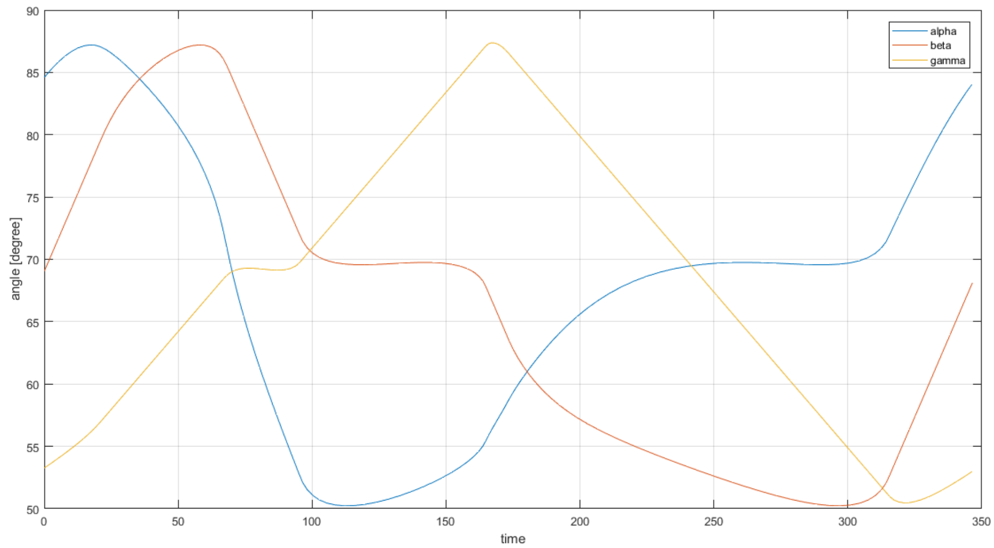

Fig.4. *The angles of the actuators depending of the time*

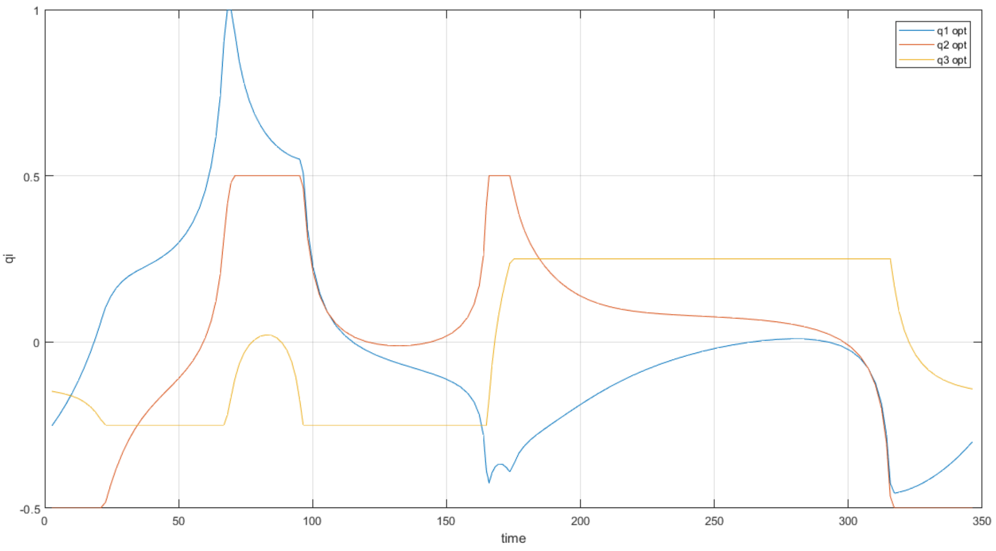

Fig.5. *The speed of the actuators depending of the time*

4. Summary

I presented the solution of geometric determination of inverse kinematic of parallel robots. I wrote a program in Matlab which can specify a general point of path and can solve the invers kinematic to these points and specify the data of the path.

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BIO-MECHATRONICS, BIONICS

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Abstract

Biomechatronics is an applied interdisciplinary science that aims to integrate biology, mechanics, and electronics. It also encompasses the fields of robotics and neuroscience. Biomechatronic devices encompass a wide range of applications from the development of prosthetic limbs to engineering solutions concerning respiration, vision, and the cardiovascular system.

1. Introduction

Biomechatronics mimics how the human body works. For example, four different steps must occur to be able to lift the foot to walk. First, impulses from the motor center of the brainare sent to the foot and leg muscles. Next the nerve cells in the feet send information, providing feedback to the brain, enabling it to adjust the muscle groups or amount of forcerequired to walk across the ground. Different amounts of force are applied depending on the type of surface being walked across. The leg's muscle spindle nerve cells then sense and send the position of the floor back up to the brain. Finally, when the foot is raised to step, signals are sent to muscles in the leg and foot to set it down.

1.1. Biosensors

Biosensors are used to detect what the user wants to do or their intentions and motions. In some devices the information can be relayed by the user's nervous system or muscle system. This information is related by the biosensor to a controller which can be located inside or outside the biomechatronic device. In addition biosensors receive information about the limb position and force from the limb and actuator. Biosensors come in a variety of forms. They can be wires which detect electrical activity, needle electrodes implanted in muscles, and electrode arrays with nerves growing through them.

1.2. Mechanical sensors

The purpose of the mechanical sensors is to measure information about the biomechatronic device and relate that information to the biosensor or controller.

1.3. Controller

The controller in a biomechatronic device relays the user's intentions to the actuators. It also interprets feedback information to the user that comes from the biosensors and mechanical sensors. The other function of the controller is to control the biomechatronic device's movements.

1.4. Actuator

The actuator is an artificial muscle. Its job is to produce force and movement. Depending on whether the device is orthotic or prosthetic the actuator can be a motor that assists or replaces the user's original muscle.

2. Research

Biomechatronics is a rapidly growing field but as of now there are very few labs which conduct research. The Rehabilitation Institute of Chicago, University of California at Berkeley, MIT, and University of Twente in the Netherlands are the researching leaders in biomechatronics. Three main areas are emphasized in the current research.
Analyzing human motions, which are complex, to aid in the design of biomechatronic devices, studying how electronic devices can be interfaced with the nervous system.
Testing the ways to use living muscle tissue as actuators for electronic devices

3. Analyzing motions

A great deal of analysis over human motion is needed because human movement is very complex. MIT and the University of Twente are both working to analyze these movements. They are doing this through a combination of computer models, camera systems, and electromyograms.
Interfacing allows biomechatronic devices to connect with the muscle systems and nerves of the user in order send and receive information from the device. This is a technology that is not available in ordinary orthotics and prosthetics devices. Groups at the University of Twente are making drastic steps in this department. Scientists there have developed a device which will help to treat paralysis and stroke victims who are unable to control their foot while walking. The researchers are also nearing a breakthrough which would allow a person with an amputated leg to control their prosthetic leg through their stump muscles.
Hugh Herr is the leading biomechatronic scientist at MIT. Herr and his group of researchers are developing a sieve integrated circuit electrode and prosthetic devices that are coming closer to mimicking real human movement. The two prosthetic devices currently in the making will control knee movement and the other will control the stiffness of an ankle joint.
Robotic fish
As mentioned before Herr and his colleagues made a robotic fish that was propelled by living muscle tissue taken from frog legs. The robotic fish was a prototype of a biomechatronic device with a living actuator. The following characteristics were given to the fish.[2]
A styrofoam float so the fish can float
A silicone tail that enables force while swimming
Power provided by lithium batteries
A microcontroller to control movement

An infrared sensor enables the microcontroller to communicate with a handheld device
Muscles stimulated by an electronic unit
The demand for biomechatronic devices are at an all-time high and show no signs of slowing down. With increasing technological advancement in recent years, biomechatronic researchers have been able to construct prosthetic limbs that are capable of replicating the functionality of human appendages. Such devices include the "i-limb", developed by prosthetic company Touch Bionics, the first fully functioning prosthetic hand with articulating joints,[3] as well as Herr's PowerFoot BiOM, the first prosthetic leg capable of simulating muscle and tendon processes within the human body.[4] Biomechatronic research has also helped further research towards understanding human functions. Researchers from Carnegie Mellon and North Carolina State have created an exoskeleton that decreases the metabolic cost of walking by around 7 percent.[5]
Many biomechatronic researchers are closely collaborating with military organizations. The US Department of Veterans Affairs and the Department of Defense are giving funds to different labs to help soldiers and war veterans.[2]
Despite the demand, however, biomechatronic technologies struggle within the healthcare market due to high costs and lack of implementation into insurance policies. Herr claims that Medicare and Medicaid specifically are important "market-breakers or market-makers for all these technologies," and that the technologies will not be available to everyone until the technologies get a breakthrough.[6] Biomechatronic devices, although improved, also still face mechanical obstructions, suffering from inadequate battery power, consistent mechanical reliability, and neural connections between prosthetics and the human body.[7]
Examples of bionics in engineering include the hulls of boats imitating the thick skin of dolphins; sonar, radar, and medical ultrasound imaging imitating animal echolocation.

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BIO-MECHATRONICS, BIONICS

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Abstract

Biomechatronics is an applied interdisciplinary science that aims to integrate biology, mechanics, and electronics. It also encompasses the fields of robotics and neuroscience. Biomechatronic devices encompass a wide range of applications from the development of prosthetic limbs to engineering solutions concerning respiration, vision, and the cardiovascular system.

Bionics is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. The study of bionics often emphasizes implementing a function found in nature rather than imitating biological structures. For example, in computer science, cybernetics tries to model the feedback and control mechanisms that are inherent in intelligent behavior, while artificial intelligence tries to model the intelligent function regardless of the particular way it can be achieved.

Keywords: bio-mechatronics, bionics, bionic humans

1. BIO-MECHATRONICS, BIONICS

1.1. Introduction

Mimicry of nature is an old idea. Many inventors have modeled machines after animals throughout the centuries. Copying from nature has distinct advantages. Most living creatures now on the Earth are the product of two billion years of evolution, and the construction of machines to work in an environmentresembling that of living creatures can profit from this enormous experience. Although the easiest way may be thought to be direct imitation of nature, this is often difficult if not impossible, among other reasons because of the difference in scale. Bionics researchers have found that it is more advantageous to understand the principles of why things work in nature than to slavishly copy details.

1.2. How it works

Biomechatronics mimics how the human body works. For example, four different steps must occur to be able to lift the foot to walk. First, impulses from the motor center of the brain are sent to the foot and leg muscles. Next the nerve cells in the feet send information, providing feedback to the brain, enabling it to adjust the muscle groups or amount of force required to walk across the ground. Different amounts of force are applied depending on the type of surface being walked across. The leg's muscle spindle nerve cells then sense and send the position of the floor back up to the brain. Finally, when the foot is raised to step, signals are sent to muscles in the leg and foot to set it down.

– **Biosensors**

  Biosensors are used to detect what the user wants to do or their intentions and motions. In some devices the information can be relayed by the user's nervous system or muscle system. This information is related by the biosensor to a controller which can be located inside or outside the biomechatronic device. In addition biosensors receive information about the limb position and force from the limb and actuator. Biosensors come in a variety of forms. They can be wires which detect electrical activity, needle electrodes implanted in muscles, and electrode arrays with nerves growing through them.

– **Mechanical sensors**

  The purpose of the mechanical sensors is to measure information about the biomechatronic device and relate that information to the biosensor or controller.

– **Controller**

  The controller in a biomechatronic device relays the user's intentions to the actuators. It also interprets feedback information to the user that comes from the biosensors and mechanical sensors. The other function of the controller is to control the biomechatronic device's movements.

– **Actuator**

  The actuator is an artificial muscle. Its job is to produce force and movement. Depending on whether the device is orthotic or prosthetic the actuator can be a motor that assists or replaces the user's original muscle.

1.3. Bionic Humans

Advances in technology make it possible to build limbs with components that mimic the function of the skeleton, musculature, tendons and nerves of the human body. Meanwhile, the sensory system can be replicated with microphones, cameras, pressure sensors and electrodes. Even that most vital organ, the heart, can be replaced with a hydraulic pump.

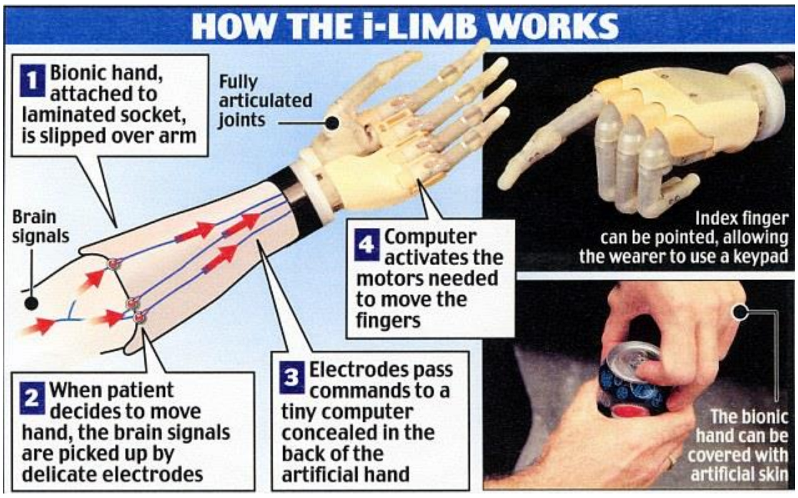
Some of the newest technologies are so advanced that the components actually outperform their biological counterparts.

1.4. Bionic Limb

Prosthetic limbs have come on leaps and bounds in the past couple of decades. They still retain characteristic features, such as an internal skeleton for structural support and a socket to attach to the amputation site, however the most innovative models are now able to reproduce, or even exceed, biological movements. Motors are used in place of muscles, springs instead of tendons and wires instead of nerves. The movement of many prosthetics is controlled externally, using cables attached to other parts of the body, or using a series of buttons and switches. New technology is emerging to allow the user to move the limb using their mind (see 'The power of thought'). The next logical step in this process is developing technology that enables the prosthetic limb to sense touch, and relay the information back to the user. DARPA-funded researchers have developed FINE, a flat interface nerve electrode (see below left) which brings nerves into close contact with electrodes, allowing sensory data to pass to the brain.

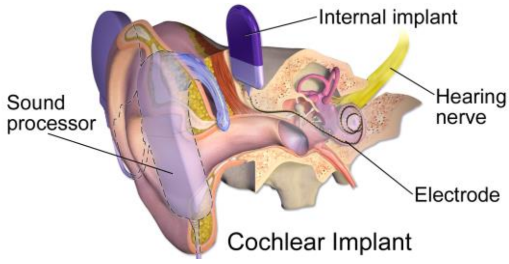
1.5. Bionic Arm

The "bionic arm" technology is possible primarily because of two facts of amputation. First, the motor cortex in the brain (the area that controls voluntary muscle movements) is still sending out control signals even if certain voluntary muscles are no longer available for control; and second, when doctors amputate a limb, they don't remove all of the nerves that once carried signals to that limb. So if a person's arm is gone, there are working nerve stubs that end in the shoulder and simply have nowhere to send their information. If those nerve endings can be redirected to a working muscle group, then when a person thinks "grab handle with hand," and the brain sends out the corresponding signals to the nerves that should communicate with the hand, those signals end up at the working muscle group instead of at the dead end of the shoulder.



1.6. Cochlear Implant

A cochlear implant has four main components. A microphone, worn near the ear, detects audio and transmits a signal to a sound processor. The processor then arranges the signal and sends it to a built-in transmitter. The transmitter passes the signal to an implanted receiver/stimulator, which transforms it into electrical stimuli for the electrodes. Finally these signals are relayed to the auditory nerve.



2. The future of bionics

– **3D-printed organs:** 3D printing is the future of manufacturing and biologists are adapting the technology in order to print using living human cells. The cells are laid down in alternating layers alongside a transparent gel-like scaffold material. As the cells fuse, the scaffold disappears.

– **Ekso skeleton:** Ekso Bionics has made bionic exoskeletons to allow people with lower limb paralysis to walk. Ekso supports their body and uses motion sensors to monitor gestures and then translate them into movement.

– **Artificial kidney:** The University of California, San Francisco, is developing a bionic kidney. At about the size of a baseball, it contains silicone screens with nano-drilled holes to fi lter blood as it passes. It will also contain a population of engineered kidney cells.

– **Man-made immunity:** Leuko-polymersomes are plastic 'smart particles' that mimic cells of the immune system. They are being designed to stick to infl ammatory markers in the body and could be used to target drug delivery to infections and cancer.

– **Robotic blood cells:** The Institute for Molecular Manufacturing is developing nanotechnology that could increase the oxygen-carrying capacity of blood. Known as respirocytes, the cells are made atom by atom – mostly from carbon.

3. Conclusion/Summary

What makes us human? Is it our bodies? Our brains? Our emotions? Or something more intangible? Advances in human bionics may eventually require us to rethink our concepts of what it is to be human, as the lines between human and machine become increasingly blurred. Yet despite the desire to imagine a future of cybernetic enhancements, at present bionic limbs remain chiefly medical devices, designed to restore function and provide people who have lost limbs with a better quality of life. The bionics may look impressively futuristic, but they are not yet able to fully replicate the complexity, range of movement and functionality of a normal human limb.

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BIO MECHATRONICS, BIONICS

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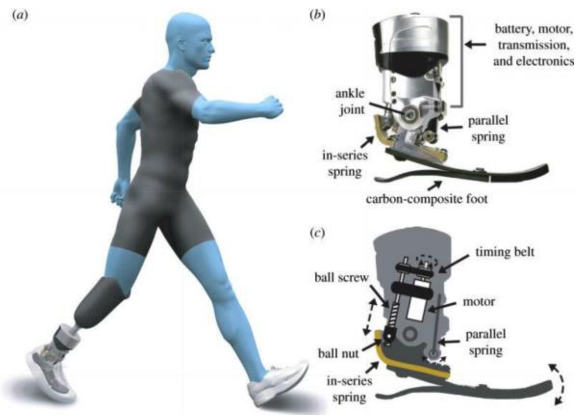
Abstract

Bio mechatronics is an applied interdisciplinary science that aims to integrate biology, mechanics, and electronics. It also encompasses the fields of robotics and neuroscience. Biomechatronic devices encompass a wide range of applications from the development of prosthetic limbs to engineering solutions concerning respiration, vision, and the cardiovascular system. It uses a wide variety of sensors, controllers and actuators to make the prosthetic limbs move as a normal leg or arm would do. Researchers are currently working on this project, to make these creations more and more efficient, lighter, smoother working and how these electronic devices could be controlled by our own will. Bionics is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. The word bionic was coined by Jack E. Steele in 1958, possibly originating from the technical term bion (pronounced BEE-on; from Ancient Greek: βίος), meaning 'unit of life' or 'like life'.

Keywords: Bio mechatronics, Bionics, mimicry, body

1. Bio mechatronics in general

Bio mechatronics **mimics** how the human body works. For example, four different steps must occur to be able to lift the foot to walk. First, impulses from the motor centre of the brain are sent to the foot and leg muscles. Next the nerve cells in the feet send information, providing feedback to the brain, enabling it to adjust the muscle groups or amount of force required to walk across the ground. Different amounts of force are applied depending on the type of surface being walked across. The leg's muscle spindle nerve cells then sense and send the position of the floor back up to the brain. Finally, when the foot is raised to step, signals are sent to muscles in the leg and foot to set it down.



1.1 Biosensors

Biosensors are used to detect what the user wants to do or their intentions and motions. In some devices the information can be relayed by the user's nervous system or muscle system. This information is related by the biosensor to a controller which can be located inside or outside the biomechatronic device. In addition, biosensors receive information about the limb position and force from the limb and actuator. Biosensors come in a variety of forms. They can be wires which detect electrical activity, needle electrodes implanted in muscles, and electrode arrays with nerves growing through them.

1.2 Mechanical sensors

The purpose of the mechanical sensors is to measure information about the biomechatronic device and relate that information to the biosensor or controller.

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The controller in a biomechatronic device relays the user's intentions to the actuators. It also interprets feedback information to the user that comes from the biosensors and mechanical sensors. The other function of the controller is to control the biomechatronic device's movements.

1.4 Actuator

The actuator is an artificial muscle. Its job is to produce force and movement. Depending on whether the device is orthotic or prosthetic the actuator can be a motor that assists or replaces the user's original muscle.

2. Research

Bio mechatronics is a rapidly growing field but as of now there are very few labs which conduct research. The Rehabilitation Institute of Chicago, University of California at Berkeley, MIT, and University of Twente in the Netherlands are the researching leaders in bio mechatronics. Three main areas are emphasized in the current research.

- Analysing human motions, which are complex, to aid in the design of biomechatronic devices;
- Studying how electronic devices can be interfaced with the nervous system;
- Testing the ways to use living muscle tissue as actuators for electronic devices.

2.1 Analysing motions

A great deal of analysis over human motion is needed because human movement is very complex. MIT and the University of Twente are both working to analyse these movements. They are doing this through a combination of computer models, camera systems, and electromyograms.

2.2 Interfacing

Interfacing allows biomechatronic devices to connect with the muscle systems and nerves of the user in order send and receive information from the device. This is a technology that is not available in ordinary orthotics and prosthetics devices. Groups at the University of Twente are making drastic steps in this department. Scientists there have developed a device which will help to treat paralysis and stroke victims who are unable to control their foot while walking.

2.3 MIT research

Hugh Herr is the leading biomechatronic scientist at MIT. Herr and his group of researchers are developing a sieve integrated circuit electrode and prosthetic devices that are coming closer to mimicking real human movement.

They made a **robotic fish** that was propelled by living muscle tissue taken from frog legs. The robotic fish was a prototype of a biomechatronic device with a living actuator. The following characteristics were given to the fish.

- A styrofoam float so the fish can float
- Electrical wires for connections
- A silicone tail that enables force while swimming
- Power provided by lithium batteries
- A microcontroller to control movement
- An infrared sensor enables the microcontroller to communicate with a handheld device
- Muscles stimulated by an electronic unit

3. Growth

The demand for biomechatronic devices are at an all-time high and show no signs of slowing down. With increasing technological advancement in recent years, biomechatronic researchers have been able to construct prosthetic limbs that can replicate the functionality of human appendages. Such devices include the "i-limb", developed by prosthetic company Touch Bionics, the first fully functioning prosthetic hand with articulating joints, as well as Herr's PowerFoot BiOM, the first prosthetic leg capable of simulating muscle and tendon processes within the human body.

Despite the demand, however, biomechatronic technologies struggle within the healthcare market due to high costs and lack of implementation into insurance policies. Biomechatronic devices, although improved, also still face mechanical obstructions, suffering from inadequate battery power, consistent mechanical reliability, and neural connections between prosthetics and the human body.

4. Bionics

Bionics is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology.

The transfer of technology between lifeforms and manufactured objects is, according to proponents of bionic technology, desirable because evolutionary pressure typically forces living organisms, to become highly optimized and efficient. A classic example is the development of dirt- and water-repellent paint (coating) from the observation that practically nothing sticks to the surface of the lotus flower plant (the lotus effect).

Examples of bionics in engineering include the hulls of boats imitating the thick skin of dolphins; sonar, radar, and medical ultrasound imaging imitating animal echolocation.

The term "biomimetic" is preferred when reference is made to chemical reactions. In that domain, biomimetic chemistry refers to reactions that, in nature, involve biological macromolecules (e.g. enzymes or nucleic acids) whose chemistry can be replicated in vitro using much smaller molecules.

4.1 Methods

The study of bionics often emphasizes implementing a function found in nature rather than imitating biological structures.

There are generally three biological levels in the fauna or flora, after which technology can be modelled:

- Mimicking natural methods of manufacture
- Imitating mechanisms found in nature
- Studying organizational principles from the social behaviour of organisms

4.2 Specific uses

4.2.1. In medicine

Bionics is a term which refers to the flow of concepts from biology to engineering and vice versa. Hence, there are two slightly different points of view regarding the meaning of the word.

In medicine, bionics means the replacement or enhancement of organs or other body parts by mechanical versions. Bionic implants differ from mere prostheses by mimicking the original function very closely, or even surpassing it.

4.2.2. Politics

A political form of biomimicry is bioregional democracy, wherein political borders conform to natural ecoregions rather than human cultures or the outcomes of prior conflicts. Biomimicry is also the second principle of Natural Capitalism.

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International Mechatronic Student Micro-Conference

Bánki Donát Faculty of Mechanical &Safety Engineering
Institute of Mechatronics & Vehicle Engineering,
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MATLAB SIMULATION OF FUZZY RULE-BASED AIR CONDITIONER CONTROL

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Abstract

Fuzzy Logic is a control logic used in matters related to systems which are difficult to control with classical methods. The air conditioner intelligent system is the control of two control parameter that is room temperature and the humidity of the area. In this article, Fuzzy Logic examined the controlling the design of the air condition system, which was difficult and complicated to construct the mathematical model.

Keywords: Fuzzy sets, modern fuzzy, fuzzy operation

1. INTRODUCTION

The Design of the industrial processes control is a dynamic model of the process of needed before anything else. However, this may not always be possible in practice. The events in the process may not be clearly known to the extent that mathematical modeling can be done, or even if a model can be established, the parameters of this model may change significantly over time. In some cases, even if the correct model is built, it can lead to complicated problems to use in controller design. When such problems are encountered, they will often use the knowledge and experience of an expert. The expert can be defined as linguistic qualifiers; Develops a flexible control mechanism in the direction of the words we often use in our daily lives, such as appropriate, fit, not very fit, high, very high, too much. Fuzzy control is based on such logical relations.

Lotfi Zadeh [1] first discovered this theory in 1965 as a mathematical study. Although initially unheard of by many scientists, this theory has developed very quickly thanks to Japanese researcher's approach to new technologies.

Mamdani [2] implemented the first application of control with fuzzy logic in 1974 with the control of the steamer. Mamdani has shown that Zadeh's approach to linguistic rules is provided in a form that is easily processed by the computer.

The application of fuzzy logic to the household appliances we use every day has saved considerable energy and time.

Today, we have found many field applications in fuzzy logic such an electronic control system, automotive industry brake systems, process planning and home electronics.

The application of fuzzy logic to the household appliances we use every day has saved considerable energy and time.

The main aim of this paper is as follows: Section 2 shows the fuzzy rule based control method. Section 3 provides air conditioner fuzzy rule based controlling process. Section 4 presents the case study. In final section represents the experimental result with discussion.

In this study, air conditioning system modeling will be examined in order to be a good example system for the basic principles of fuzzy logic control systems. Examination of small temperature variations in the time domain system that continuously affect the system output, using the fuzzy logic control system is a great importance.

2. FUZZY RULE BASED CONTROL

Fuzzy Rule Based Control(FRBC) is a method of developing a control algorithm that has been widely used in recent years. It is not appropriate to apply traditional control methods, especially in complex systems. Applying these methods in such situations is both expensive and rather difficult. From this point of view, complicated systems can be easily modeled by fuzzy logic. In many complex applications, many academic studies and applications have achieved high performance with fuzzy logic. However, fuzzy logic is directly related to experience. Correct rule bases and curriculum identification ensure that results that are closest to actual results are obtained, depending on experience. This experience can take a lot of time depending on the application. This situation should be seen as a disadvantage of fuzzy logic.

The block diagram of FRBC is shown in figure 1. The principal design parameters of a FRBC consist of scaling factors, fuzzification, rule base, and defuzzification methods, etc.

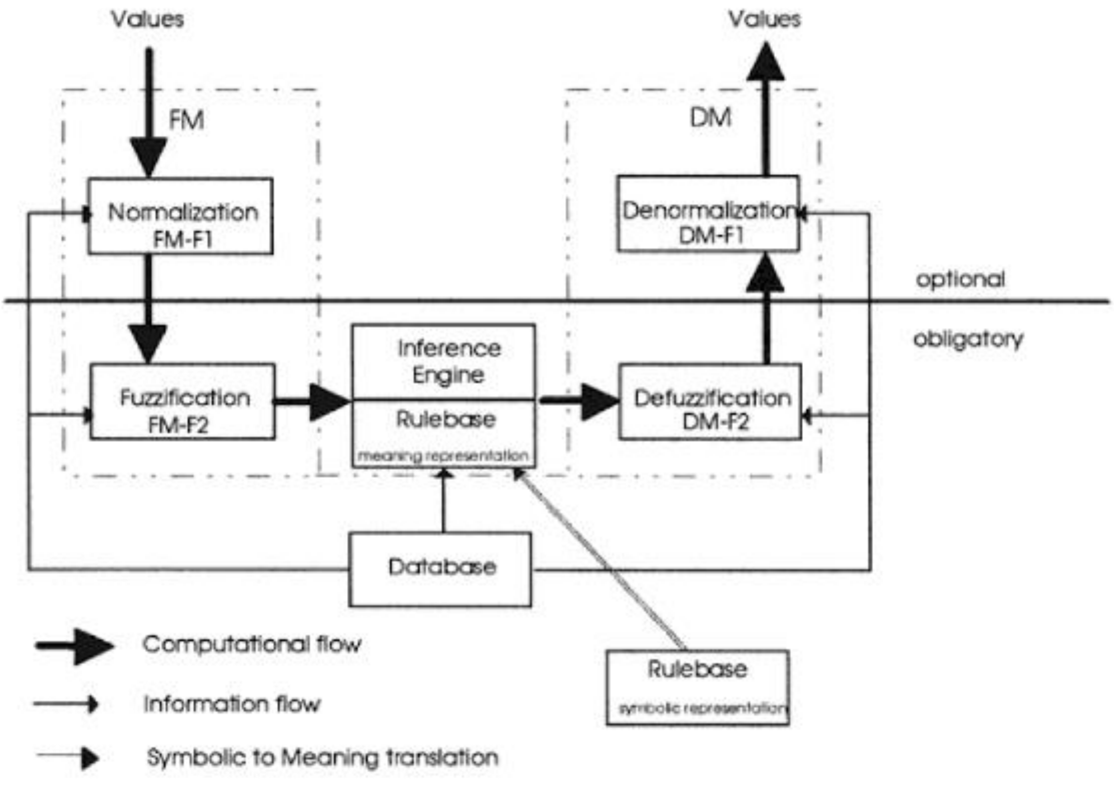

Fig.1. *The structure of a FRBC (source: [3])*

Fuzzification Module

The fuzzification module (FM) performs the following functions;

- FM-F1: Performs a scale transformation (i.e., an input normalization) which maps the physical values of the current process state variables into a normalized [4]. The scaling factors that define input normalization and output denormalization play a similar path to the gain coefficients in classical controllers. In other words, the effect on the controller's performance and stability is quite high [5]. If the non-normalized domain is used, there is no need for the FM-F1.
- FM-F2: Performs the so-called fuzzification, which is the process of converting a crisp, current value of a process state variable into a fuzzy set [6].

The Fuzzification Module, the input unit of a fuzzy controller, transforms the values of the input variables into information that can be easily used in the extraction mechanism. The fuzzification module calculates a membership level for all the fuzzy sets defined for each value of the input variables, the corresponding variable.

Database

The basic task of the database is to provide the necessary information for the observer module, the rule base, and the refinement module to perform the appropriate function. This information includes:

- Fuzzy sets (member functions) describing the verbal values of controller output and controller input variables.
- Normalization/denormalization (scaling) factors along with their physical domains and their normalized counterparts.

The creation of the database involves defining the definition range of universal sets for each variable, determining the number of fuzzy sets, and choosing membership functions [7].

Fuzzy sets divide the input and output intervals into the various permissible fuzzy values. The number of fuzzy sets defined for each variable is the most fundamental determinant of the sensitivity of a FRBC.

Rule Base

The basic structure of the rule base depends on the experience of the system operator or supervisory engineer. Fuzzy control rules in FRBC are usually "IF ... THAT IS ... (IF ... THEN)". In other words;

$$IF<process\ state>THEN<controller>output \qquad (1)$$

The "IF" part of such a rule is defined as the "CONDITION" part of the rule, and the controller input variables are included in this section within the logical integrity of the fuzzy suggestion. The "then" part of the rule is defined as the "result" part. This section also includes controller output variables [8].

Inference Engine

Determination of the control action of the fuzzy variables in the Fuzzy Logic Controller over the rules is performed by this block. In other words, this block is responsible for determining which rule will be applied and which fuzzy control action will be taken for input information received [9]. The most commonly used method is the "max-min" fuzzy inference method, with the absence of a procedure for fuzzy inference.

The Defuzzification Module

The process of transforming the control values received from the subtraction unit to the precise output and numerical values are called defuzzification [10]. The rejection module performs the exact output value detection and output denormalization [11]. The functions for the exudation module (DM) are as follows:

- DM-F1: Performs the so-called defuzzification, conversion of fuzzy values to exact values is done by this block.

- DM-F2: Normalized dominators of controller input variables are denormalized by this block. The DM-F2 block is not needed if the dominant is not normalized.

The choice of defuzzification methods is very important for the performance of the controller.

3. AIR CONDITIONER RULE BASED CONTROLLING PROCESS

An air conditioning system typical application for large control. Because the temperature and humidity control parameters interact with each other. That means the room temperature automatically change when the humidity change even it is requested value. Temperature and relative humidity RH (%) of regulators have to be associated.

The aim of air conditioning system is the controlling the temperature and humidity together. The room temperature should be between 18 and 24℃ dependent on humidity. The optimal relative humidity is in between 35 and 70 %. Usually, ıt can be realized by commanding room temperature with input air. In addition to that, people feel higher temperature more comfortable with a lower humidity with a higher humidity. The further the air conditions are out of that zone the more uncomfortable it is for people. However, the temperature difference between inside and outside should not exceed 6 K for health reasons [12].

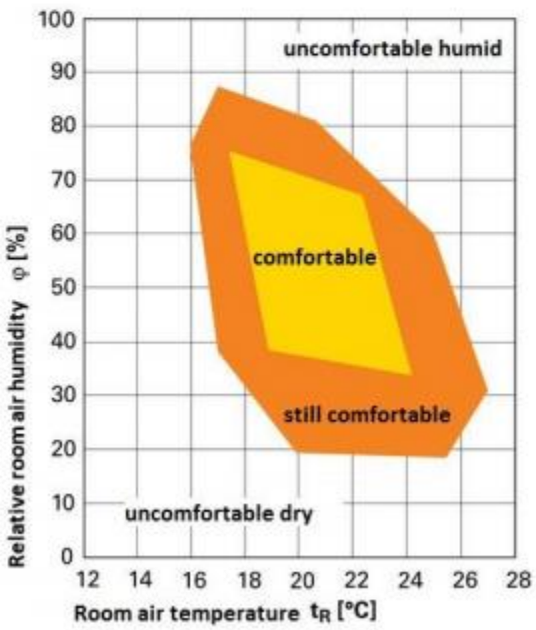

Figure.2. *Comfort zone in dependence of temperature and humidity (source: [13])*

Fuzzy logic is the favorable approach for air conditioning system. The magnitude of settings is practically incompatible, ıt can be converted to the direct concept in the linguistic term. Because people are not ingrained to specific temperature and humidity. Conversely, human accepts large area as a comfortable. Consequently, this comfort zone is the result of a person feeling relaxed in a room where the temperature is low and the humidity slightly higher.

The relative humidity is temperature dependent. It represents the ratio of the absolute water content in the air to the maximum possible water content at the same temperature. The higher the air temperature the more water the air can hold and vice versa. That means if the air gets cooled down by the air conditioners the relative humidity increases. Air conditioners also dehumidify the air by condensing water, to not end up with higher relative humidifies.

The system consists out of an indoor evaporative unit and an outdoor condensing unit. The working principle is the same as in an air/air heat pump with a hot- and a cold side. Whereas heat is rejected from inside to outside under using of electricity for operating a compressor and two fans. The transport medium is the refrigerant which evaporates at temperatures below room temperature at the inside unit. Heat energy is needed to evaporate the refrigerant until all liquid inside the evaporator has changed into steam. A compressor in the outside unit will raise the pressure and with it the temperature of the steamed refrigerant higher than the ambient temperature. At this point, the stored heat can be automatically rejected to the outside by condensing the refrigerant back into liquid. An expansion valve releases pressure and with it the temperature at the indoor unit back to the starting point. Fans on both sides support the heat transfer. The advantage of using this cycle is that more cooling capacity can be provided as electricity power it needed.

4. Case Study

Fuzzification is the process of transforming input variables and output variables into linguistic expressions. For this reason, the initial input and output variables are determined as input variables for the air conditioning system; Outdoor temperature, indoor environment temperature and humidity effects were selected and as output variables; Heater and humidifier. Determination of the linguistic expressions by giving the input and output variable degree of membership is made. The membership grades of output variables are also adjusted according to the weights of the rules. The center of gravity method is used to reach the control output variables.

It is possible to make the system more sensitive by reducing the areas covered by the specified linguistic expressions of outdoor temperature and other variables or by adding new qualifiers. The alternatives here depend on the choice of the person to implement.

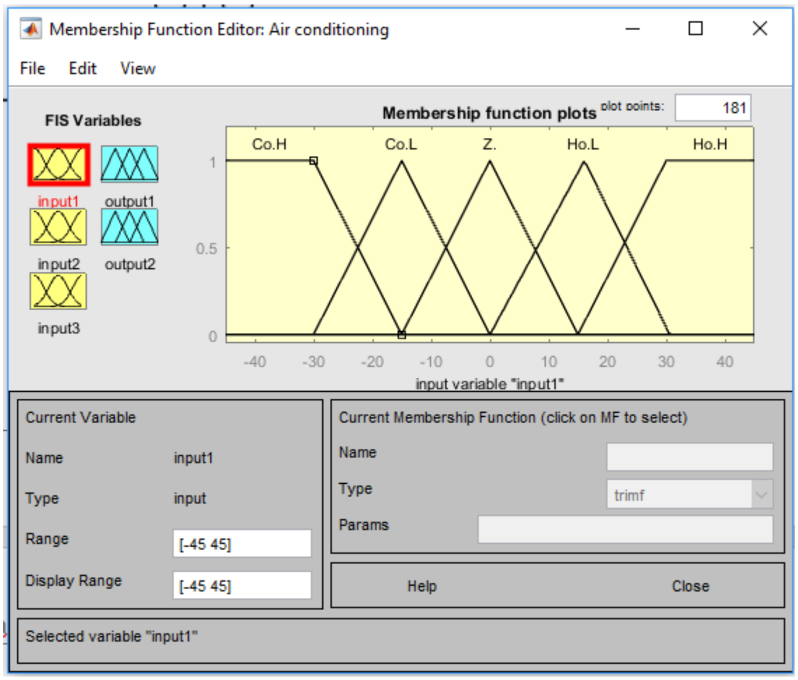

__Fig.3.__ Illustration of Outdoor Temperature Membership Functions (source: by author)

Linguistic expressions used for fuzzification the indoor temperature; cold, normal and hot. Membership functions here are at the discretion of the practitioner [14]. Different values can be given according to the area where the system is used and linguistic expressions can be increased. For example, different linguistic qualifiers and values for a system to be applied only for the temperature control of electronic devices, different linguistic qualifiers and values can be created for a system to be designed for human health. Function definitions for indoor temperature are shown in Figure 4.

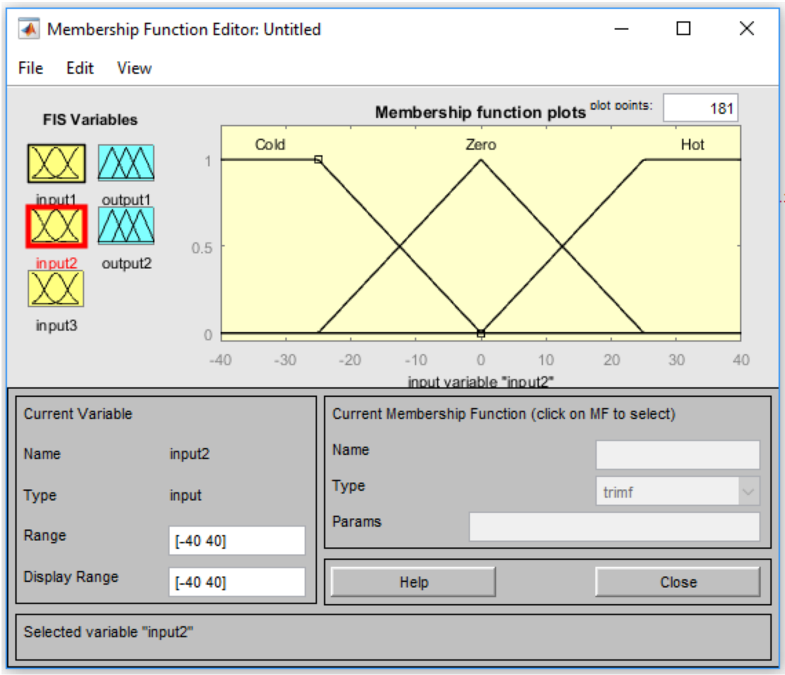

__Fig.4.__ Illustration of Indoor Temperature Membership Functions (source: by author)

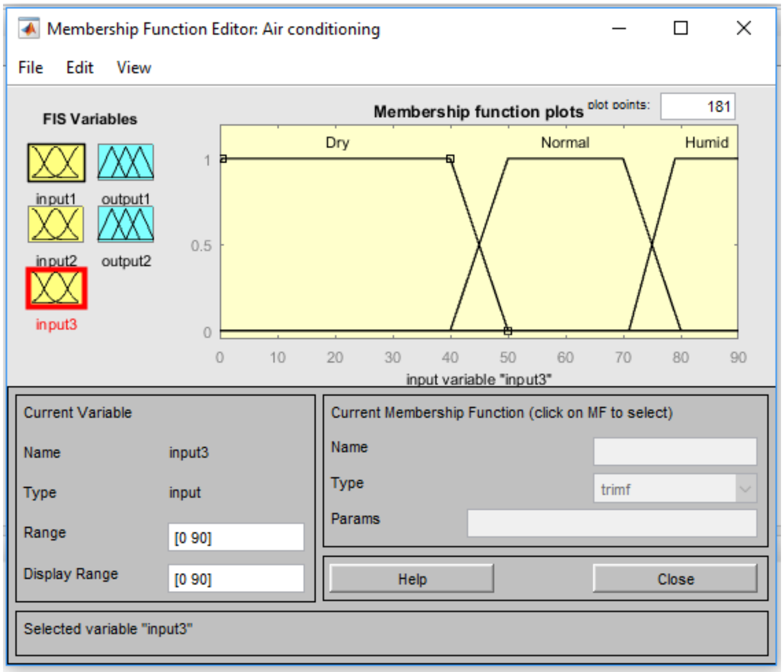

Fig.5. *Illustration of Membership Functions of Humidity Effect (source: by author)*

Table 1. Rule Table of the Air Condition

Input1	***Input2***	***Input3***	***Output1***	***Output2***
Cold High	Cold	Dry	Cold	Dry
Cold Low	Zero	Normal	Zero	Normal
Zero	Hot	Humid	Hot	Humid
Hot Low				
Hot High				

As the rule base for the air conditioning model, the expert opinion or the operator was created according to his or her wishes by giving numbers to linguistic expressions.

5. Discussion

The major problems that arise in the design of control systems are that it is difficult and complex to construct the mathematical model of the system to be controlled. It has been observed that the temperature and humidity of the heat exchange accordingly observed to be softer and the mechanisms for changing the desired humidity value has enabled us to get faster.

The biggest problem encountered with Fuzzy Logic control is that it is possible to pull system performance to a good level only by trial and error method and time loss when expertise is not utilized in creating system parameters to be controlled. This problem has also been encountered in this study and many trials and error methods have been implemented to improve the performance criterion.

In Figure 6., the input-output function is represented in three-dimensional space according to the rules and process definitions used in the membership functions given in the Surface Viewer display. Here, the output value corresponding to the point where both input values intersect is shown.

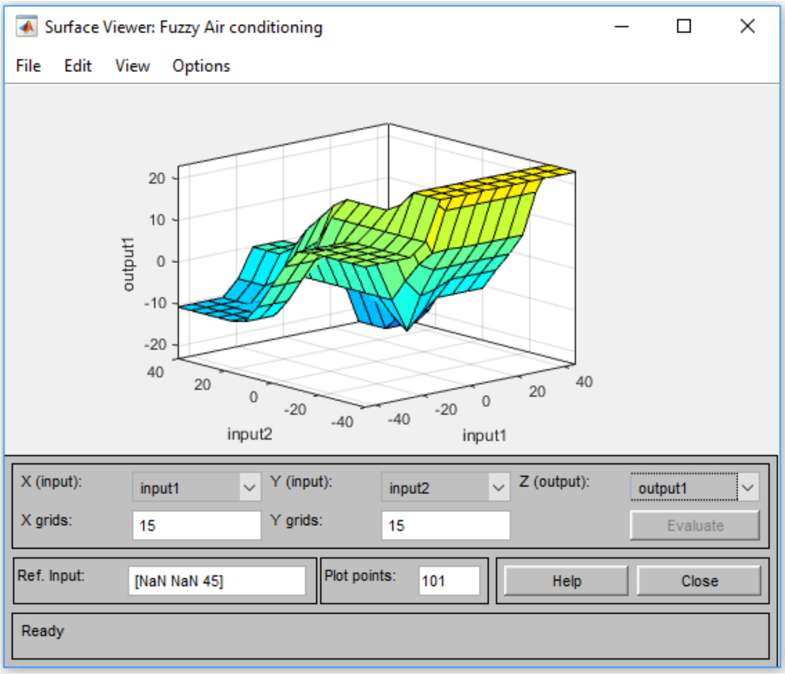

Fig.6*. Three dimension of inputs and output*

6. Conclusion, Future Work

This paper considered a method of controlling the design of the air conditon system with application of fuzzy logic. The simulation was prepared in Fuzzy Logic Toolbox of MATLAB package program to observe the results related to the system.

Research and applications related to air conditioning are generally concerned with temperature control for electronic devices. Since there is no convenience for electronic devices, it is sufficient to keep the temperature and the humidity of these instruments constant. Therefore, studies are formed generally to temperature and humidity. In this study, it was tried to provide a more comfortable environment for the air conditioner and therefore the study was carried out considering cold, hot and humidity effects.

The author will be following tasks;

- To work out traditional deffuzification methods based on risk assessment
- To determine the risk context and acceptability, use defuzzificatıon to mınımıze the overall loses
- To use the Summarızed defuzzification process in fuzzy decision makıng, Fuzzy Faılure Mode, and Effect analysıs.

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Bánki Donát Faculty of Mechanical &Safety Engineering

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MECHATRONICS IN VEHICLE ENGINEERIG: PERFORMACE AND SAFETY

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Abstract

Most of people today spend lot of time with their Automobiles. Everyone's expectations is for better performance, safe to drive, user friendly, security and of course better emissions in the ongoing development of Automobiles. Modern mechatronics can be applied to make their expectations come true with smarter mechanisms, via improved efficiencies and system interaction. This paper will cover two separated parts from vehicle engineering: the performace of vehicles' engines and the safety of vehicles, according to the developing mechatronical parts and systems nowadays. Both the evolution in vehicle performace and improvement in safety will be representated due to the technical development in mechatroical systems. The main parts of performance improvement is the smarter and smarter ECUs, ignition systems and fuel injection systems. The most common safety systems are the ABS, ESP and the airbag systems, which can be find in almost all vehicles made after the middle of 1990s, and nowadays they are the most basic systems for both drivers' and passenger safety.

Keywords: ECU, ignition, fuel injection, ABS, ESP, airbag

1. Introduction

Automotive systems are at the base of world's mobility. At present, the energetic issues related to internal combustion engines require special attention to reduce fuel consumption and contemporary increase the vehicle's performance. To achieve these goals it is necessary to introduce smart systems in the internal combustion engine powertrain that allow controlling and improving its performance both in terms of energetic efficiency and mass reduction. The apexes of this type of system are the hybrid and full electric powertrains. The development of hybrid powertrains has become a primary target for many automotive industries but the optimal solution is still far from commercial applications. Another key aspect in automotive mobility is the compromise between handling and comfort. The vehicle's suspension plays an important role in this sense, and commercial oil dampers are designed to match a specification that is not optimal for a large range of manoeuvring conditions.

2. Vehicle engine performance

2.1. – Ignition systems

An **ignition system** generates a spark or heats an electrode to a high temperature to ignite a fuel-air mixture in spark ignition internal combustion engines oil-fired and gas-fired boilers, rocket engines, etc. The widest application for spark ignition internal combustion engines is in petrol road vehicles.

Compression ignition Diesel engines ignite the fuel-air mixture by the heat of compression and do not need a spark. They usually have glowplugs that preheat the combustion chamber to allow starting in cold weather.

2.1.1. – Magneto ignition

The simplest form of spark ignition is that using a magneto. The engine spins a magnet inside a coil, or, in the earlier designs, a coil inside a fixed magnet, and also operates a contact breaker, interrupting the current and causing the voltage to be increased sufficiently to jump a small gap. The spark plugs are connected directly from the magneto output.

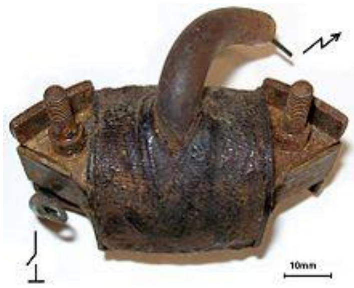

Fig.2.1.1. *An early magneto-type ignition coil*

2.1.2. – Mechanically timed ignition

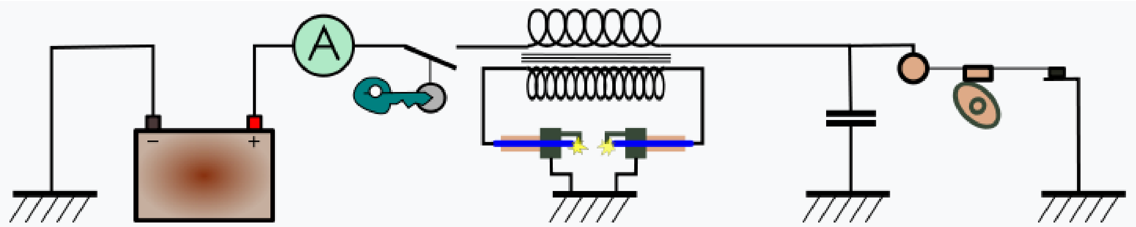

Fig.2.1.2.1. *Schematic illusttration of mechanically timed ignition*

Most four-stroke engines have used a mechanically timed electrical ignition system. The heart of the system is the distributor. The distributor contains a rotating cam driven by the engine's drive, a set of breaker points, a condenser, a rotor and a distributor cap. External to the distributor is the ignition coil, the spark plugs and wires linking the distributor to the spark plugs and ignition coil.

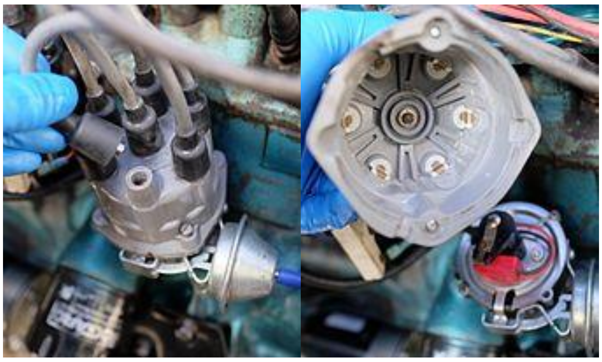

Fig.2.1.2.2. *Distributor cap with wires and terminal. Rotor contacts inside distributor cap.*

2.1.3. – Electronic ignition

The disadvantage of the mechanical system is the use of breaker points to interrupt the low-voltage high-current through the primary winding of the coil; the points are subject to mechanical wear where they ride the cam to open and shut, as well as oxidation and burning at the contact surfaces from the constant sparking.

Fig.2.1.3. *EI coil pack (Honda)*

Electronic ignition (EI) solves these problems. In the initial systems, points were still used but they handled only a low current which was used to control the high primary current through a solid state switching system. Soon, however, even these contact breaker points were replaced by an angular sensor of some kind - either optical, where a vaned rotor breaks a light beam, or more commonly using a ***Hall effect*** sensor, which responds to a rotating magnet mounted on the distributor shaft.

2.1.4. – Digital electronic ignition

At the turn of the 21st century digital electronic ignition modules became available for small engines on such applications as chainsaws, string trimmers, leaf blowers, and lawn mowers. This was made possible by low cost, high speed, and small footprint microcontrollers. Digital electronic ignition modules can be designed as either capacitor discharge ignition (CDI) or inductive discharge ignition (IDI) systems. This allows for greater timing flexibility, and engine performance. So, we can expect the newes generation of ignition systems in this form.

2.2. – Engine Controlling

2.2.1. – Engine electronics

Automotive engine electronics originated from the need to control engines. The first electronic pieces were used to control engine functions and were referred to as engine control units (ECU). As electronic controls began to be used for more automotive applications, the acronym ECU took on the more general meaning of "electronic control unit", and then specific CUs were developed. Now, CUs are modular. A modern car may have up to 100 CU's. Automotive electronics or automotive embedded systems are distributed systems, and according to different domains in the automotive field, they can be classified into:

- Engine electronics
- Transmission electronics
- Chassis electronics
- Active safety
- Driver assistance
- Passenger comfort
- Entertainment systems
- Electronic Integrated Cockpit systems

2.2.2. – ECU /Engine Controlling Unit/

Early EMS systems used an analogue computer to accomplish the signals from those basic sensors which needed to run the engine, but as embedded systems dropped in price and became fast enough to keep up with the changing inputs at high revolutions, digital systems started to appear.

An ECU is a computer designed to control ignition and injection in an engine. It plays a central role in an EFI system, much like a carburetor and a distributor did in a mechanical system.

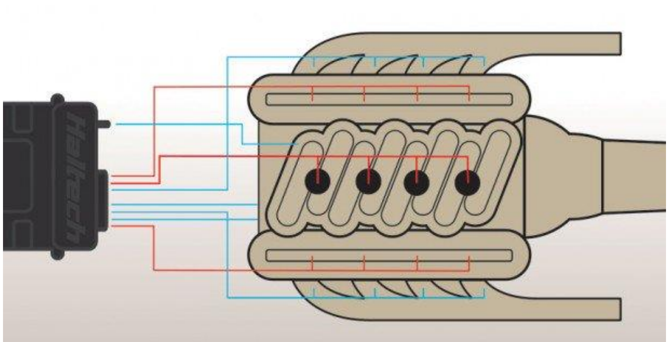

Fig.2.2.2.1. *ECU's connections to the engine*

Like any computer, an ECU has a bunch of inputs and outputs. Inputs are connected to a wide array of sensors on the engine which provide the ECU with essential engine information.

The most basic sensors needed for an engine to run are:

- Air Temperature
- Coolant Temperature

- Throttle Position
- Manifold Pressure
- Engine Speed

Once the sensor information is received and processed using a fuel and ignition table, signals are sent out via the ECU's outputs to the fuel and ignition system.

Basic ECU outputs will control:

- Fuel Injectors
- Ignition Coils

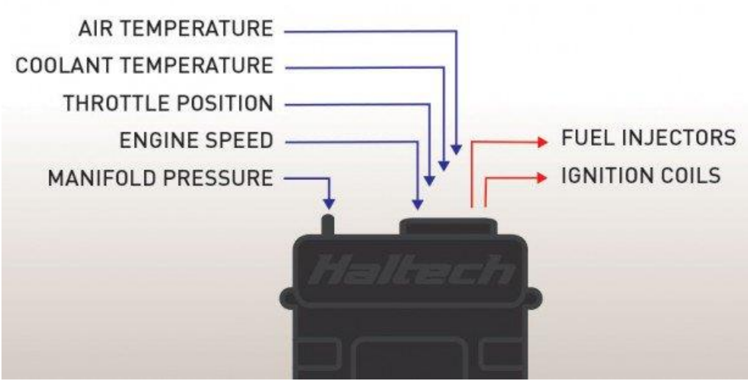

Fig.2.2.2.2. *ECU's signal input (blue) and outputs(red)*

The outgoing signal tells the injectors how much fuel to provide in order to achieve the desired air-to-fuel ratio. It also tells the ignition coils when to fire in order for the spark to occur at the right time.

Tuning or Calibrating of an ECU is usually done via an external computer and involves setting up a "Lookup Table". This table normally will have a load (RPM) axis and a throttle position or manifold pressure (load reference) axis. With these a tuner will be able to map ignition timing and the amount of fuel needed at each interval. Once completed, these tables will allow an engine to operate at its optimum under a wide range of conditions.

Fig.2.2.2.3. *ECU's calibrating (reprogramming, remapping)*

[Ide írhat]

3. Vehicle safety

3.1. – Airbag

The goal of an airbag is to inflate rapidly during automobile collision and prevent the passenger's from striking interior objects. Majority cases of death are due to air bags and seat belt is not worn.

The bag itself is made up of a thin nylon fabric, which is folded into the steering wheel or dashboard or, more recently, the seat or door.
Advance systems have solid state crash sensors that contain:

- a piezoelectric crystal
- a micro machined accelerometer
- a device used to measure acceleration;
- vibration shock built into a microchip that produces an electrical signal when jolted.

Airbag serve as a Supplemental Restraint System (SRS) which is secondary to the seatbelt system.
When a crash happens, sensors send data to a central „brain" (Called the Airbag Control Unit). The ACU evaulates all incoming information to decide if airbag deployment is necessary, and if needed deploy specific airbags.

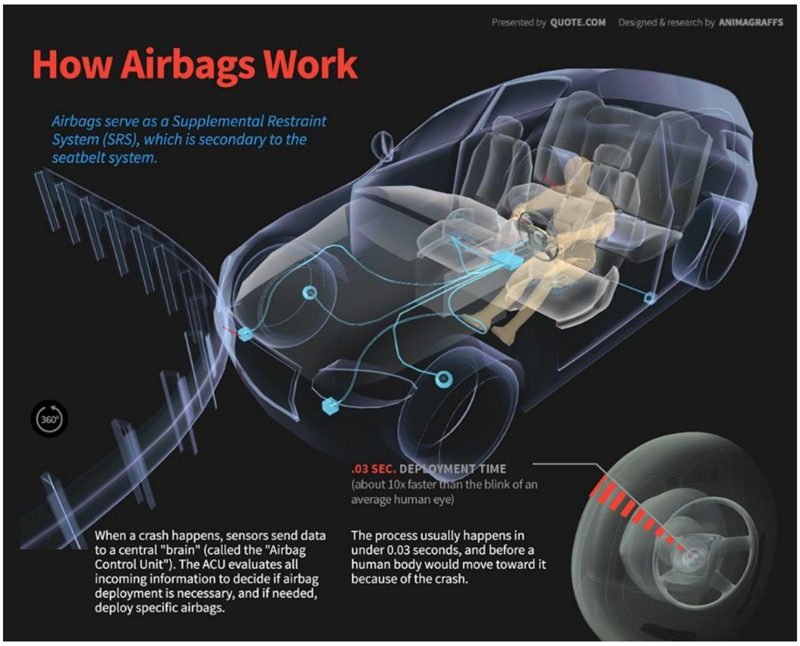

Fig.3.1. *Airbag system*

3.2. – ABS /Anti-lock Braking System/

ABS prevents locking of wheels during braking. During severe braking or on slippery surfaces, wheels approach lockup. At that time, ABS takes over. ABS modulates the brake line pressure independent of the pedal force, to bring the wheel speed back to the slip level range that is necessary for optimal braking performance.

[Ide írhat]

ABS consists of:

- Wheel Speed Sensors
- Controller Unit
- Hydraulic Modulator Unit
- Braking Device (generally mechanical parts)

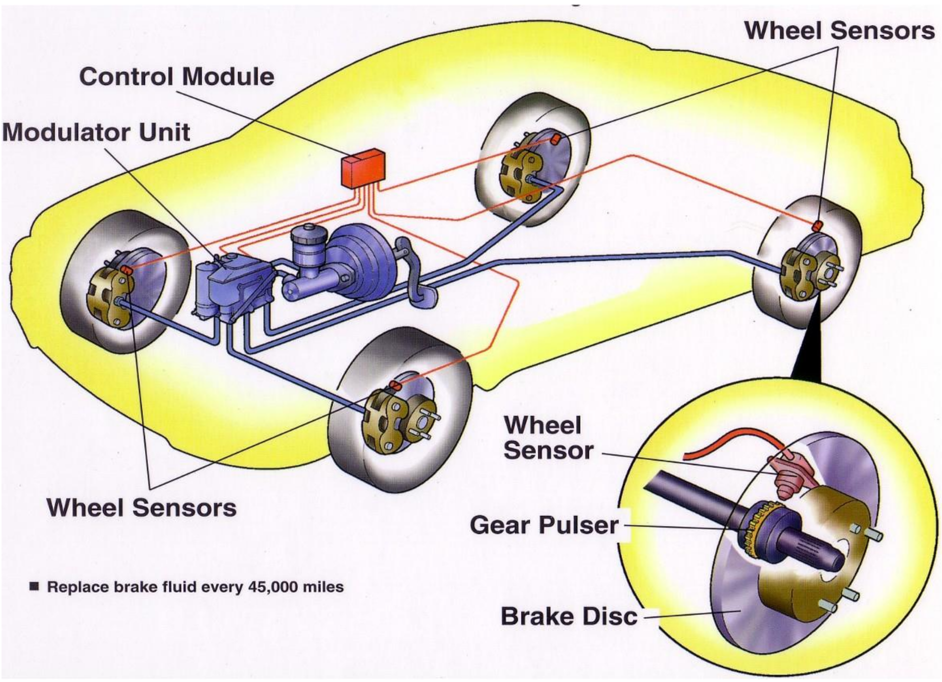

Fig.3.2. *ABS system*

3.2.1. – Wheel Speed Sensors

- Electro-magnetic or Hall-effect pulse pickups with toothed wheels mounted directly on the rotating components of the drivetrain or wheel hubs.
- As the wheel turns the toothed wheel (pulse ring) generates an AC voltage at the wheel-speed sensor.
- The voltage frequency is directly proportional to the wheel's rotational speed.

3.2.2. – Electronic Controller Unit

- The electronic control unit receives, amplifies and filters the sensor signals for calculating the wheel rotational speed and acceleration.
- ABS is usually implemented here.
- ECU assists the vehicle operator to prevent wheel lockup by regulating the wheel slip.

3.2.3. – Hydraulic Unit

- The hydraulic pressure modulator is an electro-hydraulic device for reducing, holding, and restoring the pressure of the wheel brakes by manipulating the solenoid valves in the hydraulic brake system.
- Hydraulic unit actuates the brakes by increasing the hydraulic pressure or bypassing the pedal force to reduce the braking power.

- Depending on the design, this device may include a pump, motor assembly, accumulator and reservoir

3.2.4. – How ABS works

When a wheel lockup is detected or eminent, ECU commands HCU to release the brake pressure to allow the wheel velocity to increase and the wheel slip to decrease.

Once the wheel velocity spins up, ECU re-applies the brake pressure to confine the wheel slip to a predetermined value or interval.

HCU Controls hydraulic brake pressure to each disc brake caliper or wheel cylinder based on input from the system sensors, thereby controlling wheel speed.

3.3. – ESP /Electronic Stability Control/

The Electronic Stability Program (ESP) is a closed-loop system designed to improve vehicle handling and braking response through programmed intervention in the braking system and/or drivetrain. When ESP detects loss of steering control, it automatically applies the brakes to help "steer" the vehicle where the driver intends to go. Braking is automatically applied to wheels individually, such as the outer front wheel to counter oversteer or the inner rear wheel to counter understeer. Some ESP systems also reduce engine power until control is regained. ESP does not improve a vehicle's cornering performance; instead, it helps to minimize the loss of control.

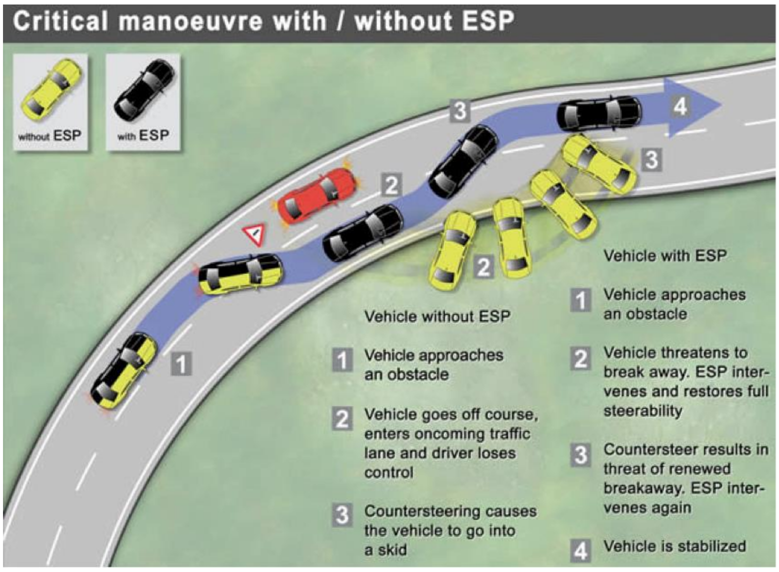

Fig.3.3. *A vehicle's movement during a critical manoeuvre*

3.3.1. – Hydraulic unit with attached control unit:

The hydraulic unit executes the commands from the control unit and regulates, via solenoid valves, the pressure in the wheel brakes. The hydraulic modulator is the hydraulic connection between the master cylinder and the wheel cylinders. It is located in the engine compartment. The control unit takes over the electrical and electronic tasks as well as all control functions of the system.

3.3.2. – Wheel-speed sensor

The control unit uses the signals from the wheel-speed sensors to compute the speed of the wheels. Two different operating principles are used: passive and active wheel-speed sensors (Inductive and Hall-effect sensors). Both measure the wheel speed in a contact-free way via magnetic fields. Nowadays active sensors are mostly employed. They can identify both the direction of rotation and the standstill of a wheel.

3.3.3. – Steering-angle sensor

The task of the steering-angle sensor is to measure the position of the steering wheel by determining the steering angle. From the steering angle, the vehicle speed and the desired braking pressure or the position of the accelerator pedal, the driving intention of the driver is calculated (desired state).

3.3.4. – Yaw-rate and lateral-acceleration sensor

A yaw-rate sensor registers all the movements of the vehicle around its vertical axis. In combination with the integrated lateral-acceleration sensor, the status of the vehicle (actual state) can be determined and compared with the driver's intention.

3.3.5. – Communication with engine management

Via the data bus, the ESP control unit is able to communicate with the engine control unit. In this way, the engine torque can be reduced if the driver accelerates too much in certain driving situations. Similarly, it can compensate for excessive slip of the driven wheels provoked by the engine drag torque.

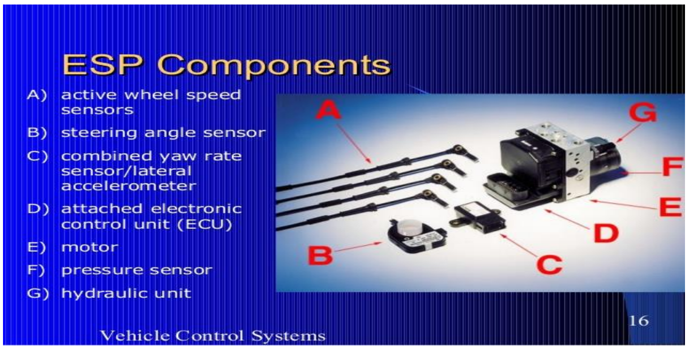

Fig.3.3.5. *ESP components*

4. – Conclusion

Mechatronics can be defined as the intersection of mechanics, electronics, computers and controls. The synergistic use of aspects of each of these fields in designing products and processes is driving advances in automobiles - the actual cars and components, as well as the equipment needed to build, diagnose and service them.

According to the technical developement in mechatronics as a science in previous decades, we can clearly see that the spread of mechatronical systems are indisputable in vehicle engineering, and as the progression continues, we can expect more and more new possibilities to improve automobiles' technology, inculding both the performance and the safety.

[Ide írhat]

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Actuators used in Mechatronic Systems

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Abstract

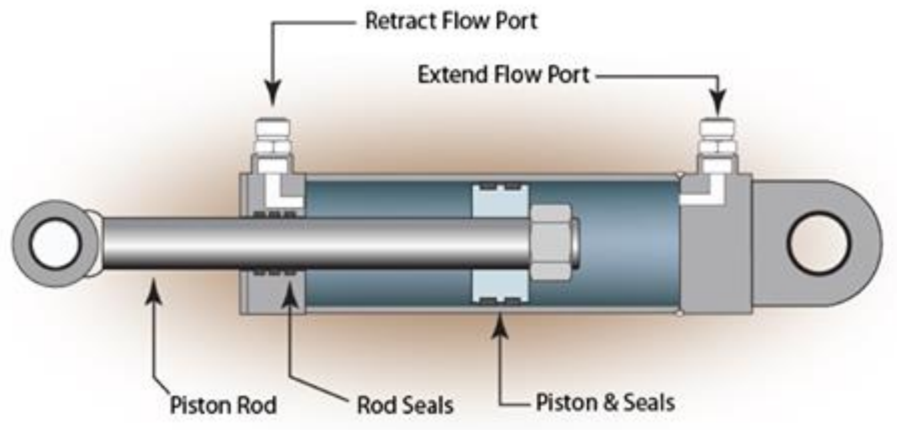
An actuator is a component of a machine that is responsible for moving or controlling a mechanism or system, for example by actuating (opening or closing) a valve; in simple terms, it is a "mover". An actuator requires a control signal and a source of energy. The control signal is relatively low energy and may be electric voltage or current, pneumatic or hydraulic pressure, or even human power. The supplied main energy source may be electric current, hydraulic fluid pressure, or pneumatic pressure. When the control signal is received, the actuator responds by converting the energy into mechanical motion. An actuator is the mechanism by which a control system acts upon an environment. The control system can be simple (a fixed mechanical or electronic system), software-based (e.g. a printer driver, robot control system), a human, or any other input.

1. Actuators

1.1. Hydraulic

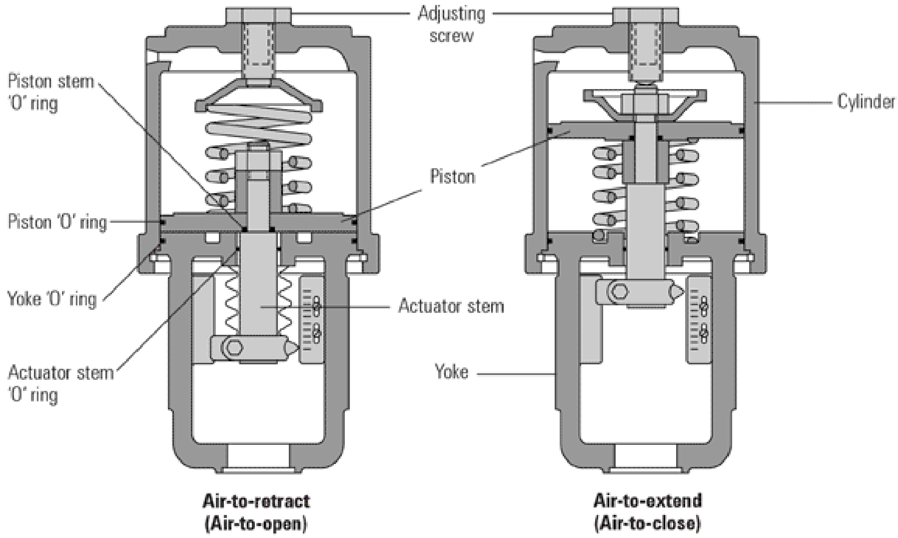
A hydraulic actuator consists of cylinder or fluid motor that uses hydraulic power to facilitate mechanical operation. The mechanical motion gives an output in terms of **linear** (Linear motion (also called rectilinear motion) is a one-dimensional motion along a straight line, and can therefore be described mathematically using only one spatial dimension), **rotatory (**Rotational motion is motion which follows a curved path. This is in stark contrast with linear motion, which follows straight paths. Linear motion is generally one's first introduction into the physics of motion. There are many parallels to be made between the two) or **oscillatory (**Oscillation is the repetitive variation, typically in time, of some measure about a central value (often a point of equilibrium) or between two

or more different states) motion. As liquids are nearly impossible to compress, a hydraulic actuator can exert a large force. The drawback of this approach is its limited acceleration.
The hydraulic cylinder consists of a hollow cylindrical tube along which a piston can slide. The term *single acting* is used when the fluid pressure is applied to just one side of the piston. The piston can move in only one direction, a spring being frequently used to give the piston a return stroke. The term *double acting* is used when pressure is applied on each side of the piston; any difference in pressure between the two sides of the piston moves the piston to one side or the other.



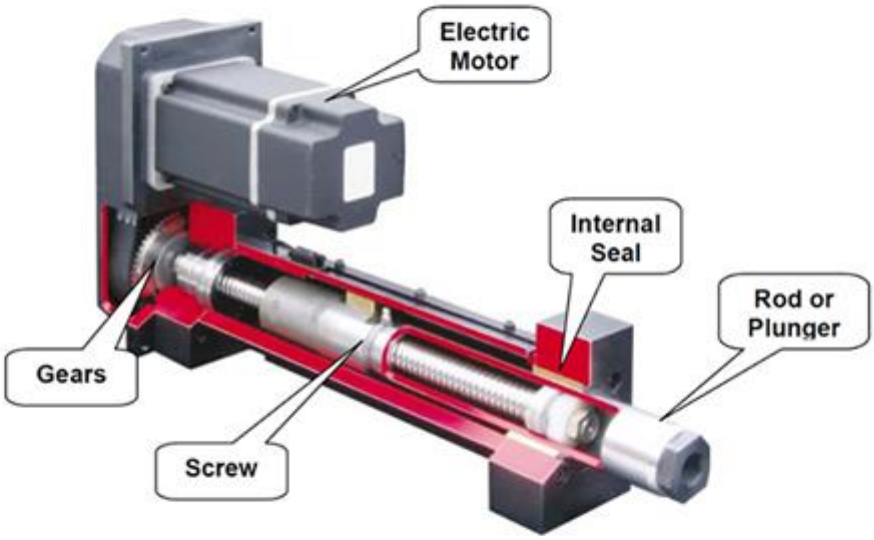
1.2.Pneumatic

A Pneumatic actuator mainly consists of a piston or a diaphragm which develops the motive power. It keeps the air in the upper portion of the cylinder, allowing air pressure to force the diaphragm or piston to move the valve stem or rotate the valve control element. Valves require little pressure to operate and usually double or triple the input force. The larger the size of the piston, the larger the output pressure can be. Having a larger piston can also be good if air supply is low, allowing the same forces with less input. These pressures are large enough to crush objects in the pipe. On 100 kPa input, you could lift a small car (upwards of 1,000 lbs) easily, and this is only a basic, small pneumatic valve. However, the resulting forces required of the stem would be too great and cause the valve stem to fail. This pressure is transferred to the valve stem, which is connected to either the valve plug (see plug valve), butterfly valve etc. Larger forces are required in high pressure or high flow pipelines to allow the valve to overcome these forces, and allow it to move the valves moving parts to control the material flowing inside. The valves input is the "control signal." This can come from a variety of measuring devices, and each different pressure is a different set point for a valve. A typical standard signal is 20–100 kPa. For example, a valve could be controlling the pressure in a vessel which has a constant out-flow, and a varied in-flow (varied by the actuator and valve). A pressure transmitter will monitor the pressure in the vessel and transmit a signal from 20–100 kPa. 20 kPa means there is no pressure, 100 kPa means there is full range pressure (can be varied by the transmitters calibration points). As the pressure rises in the vessel, the output of the transmitter rises, this increase in pressure is sent to the valve, which causes the valve to stroke downward, and start closing the valve, decreasing flow into the vessel, reducing the pressure in the vessel as excess pressure is evacuated through the out flow. This is called a direct acting process.



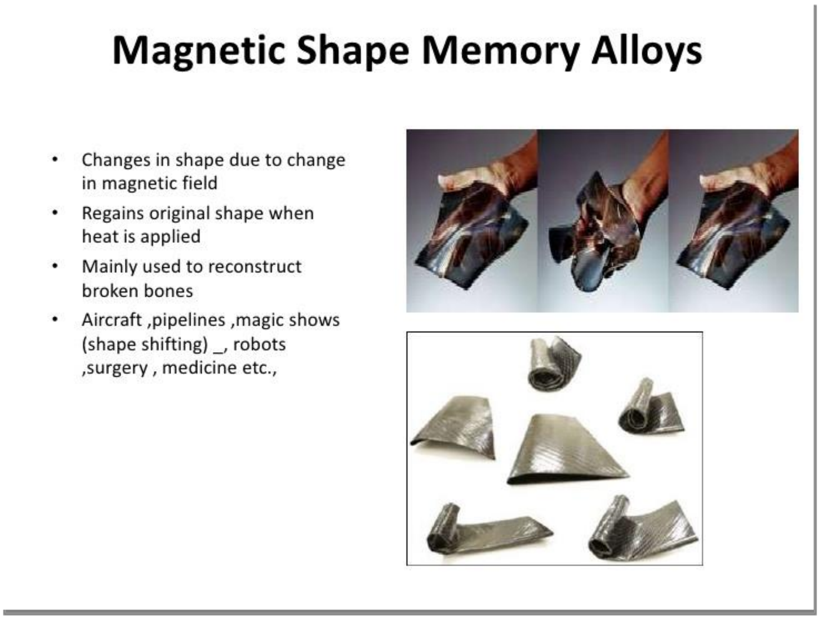
1.3. Electric

An electric actuator is powered by a motor that converts electrical energy into mechanical torque. The electrical energy is used to actuate equipment such as multi-turn valves. Electric actuators are more cost-effective than their hydraulic and pneumatic counterparts. Electric actuators benefit from cleaner, simpler, and more energy-efficient power transmission. Electric actuator integration is easier with programmable controls, and maintenance is minimized with no parts replacement or lubrication needed except in extreme conditions.



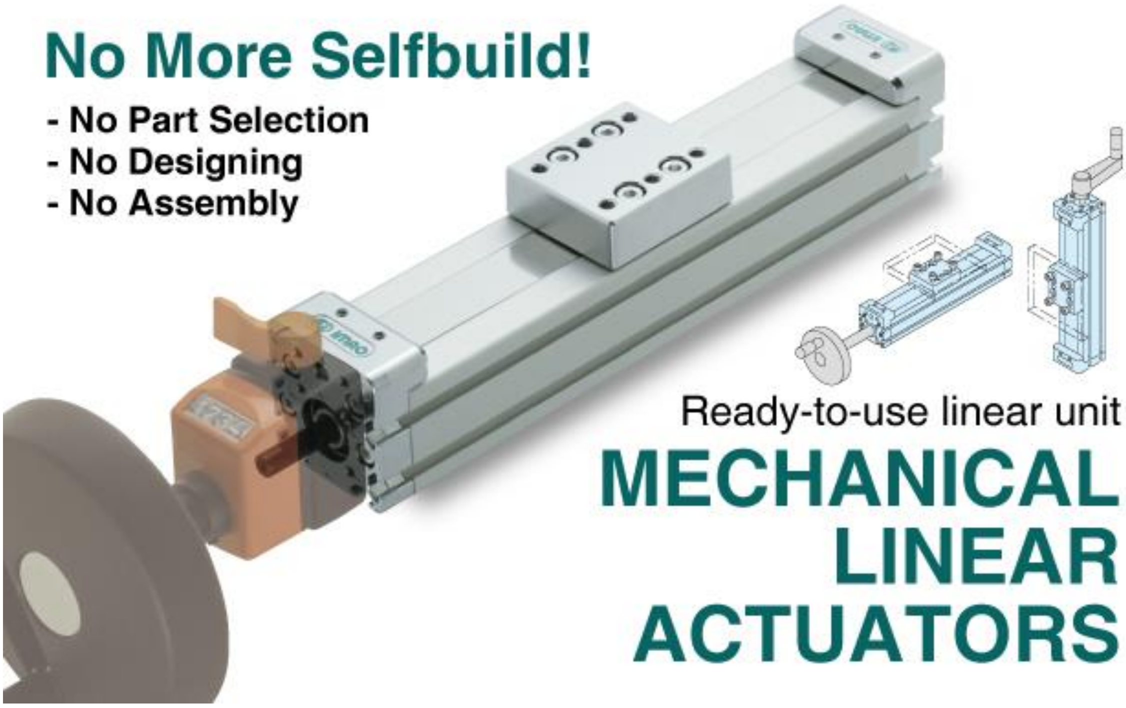
1.4. Thermal or magnetic (shape memory alloys)

Actuators which can be actuated by applying thermal or magnetic energy have been used in commercial applications. Thermal actuators tend to be compact, lightweight, economical and with high power density. These actuators use shape memory materials (SMMs)(Materials which can remember its origenal shape, and acan revert to the pre-deformed shape by external stimulus, temperture, light, voltage, etc..), such as shape memory alloys (SMAs) or magnetic shape-memory alloys(MSMAs). Some popular manufacturers of these devices are Finnish Modti Inc., American Dynalloy and Rotork.



1.5. Mechanical

A mechanical actuator functions to execute movement by converting one kind of motion, such as rotary motion, into another kind, such as linear motion. An example is a rack and pinion. The operation of mechanical actuators is based on combinations of structural components, such as gears and rails, or pulleys and chains.



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NANO MEDICINE

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Abstract

Nanotechnology, along with related concepts such as nanomaterials, nanostructures and nanoparticles, has become a priority area for scientific research and technological development. Nanotechnology, i.e., the creation and utilization of materials and devices at nanometer scale, already has multiple applications in electronics and other fields. However, the greatest expectations are for its application in biotechnology and health, with the direct impact these could have on the quality of health in future societies. The emerging discipline of Nano medicine brings nanotechnology and medicine together in order to develop novel therapies and improve existing treatments. In Nano medicine, atoms and molecules are manipulated to produce nanostructures of the same size as biomolecules for interaction with human cells. This procedure offers a range of new solutions for diagnoses and "smart" treatments by stimulating the body's own repair mechanisms. It will enhance the early diagnosis and treatment of diseases such as cancer, diabetes, Alzheimer's, Parkinson's and cardiovascular diseases. Preventive medicine may then become a reality.

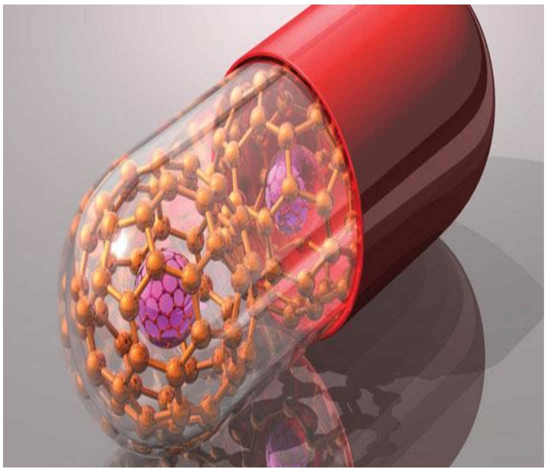
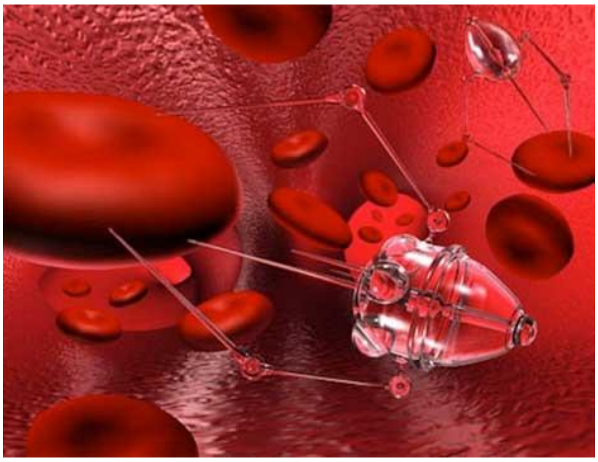
Keywords: Nano medicine; nanostructures; early diagnosis; drug deliver.

1. Nano-Medicine, its application and advantages.

1.1. Nano technology

Nanotechnology simply refers to the science of manipulating matter, more specifically atoms, at the nanoscale. Nanotechnology simply refers to matter in the size range of 1–100 nm. Nanotechnology is a new field of science and engineering that has led to innovative approaches in many areas of medicine, transport, communication and almost every aspect of human lives that involves technology. Nano technology has positively influenced many activities we perform as human beings. However it is well known that your health is your life, and for that matter it is very important for us to invest into our health status if we really want to live long. This concept however drove engineers into finding possible means and ways to help us live healthier and longer lives, thus the introduction of Nano medicine.

1.2. Nano Medicine

Nanomedicine therefore is a branch of medicine that applies the knowledge and tools of nanotechnology to the prevention and treatment of disease. Nanomedicine involves the use of nanoscale materials, such as nanorobots and biocompatible nanoparticles, for diagnosis, delivery, sensing or actuation purposes in a living organism. Nano medicine applications are grouped below in three interrelated areas: analytical/diagnostic tools, drug delivery and regenerative medicine.

1.3. Applications and Advantages

1.3.1. Analytical and Diagnostic Tools

Counting year's back, a very well-known disease, Ebola took away the lives of many people in the world, especially some African countries. This is as a result of the lack of diagnostic technology. The limitations of current diagnostic technology mean that some diseases can only be detected when at a very advanced stage. The application of Nano biotechnology in medical diagnostics can be subdivided into two broad categories: *In vitro* diagnostic devices and *in vivo* imaging. Research in this field is highly multi-disciplinary and there are close relationships among diagnostics, drug release and regenerative medicine, which are described in the following sections

1.3.2. In Vitro Diagnostic Devices

The resulting improvements in methods to characterize cells or cell compartments *in vitro* (e.g., microscopy, optical and luminescence, electron microscopy etc.) have been very crucial for the development of Nano medicine. The miniaturization and integration of different functions in a single device, based on nanotechnology-derived techniques, have led to a new generation of devices that are cheaper, faster and smaller, require no special craft and give accurate readings. The use of In Vitro diagnostic devices in research has become a normality and has improved our understanding of the molecular basis of disease and helped to identify new therapeutic targets. *In vitro* diagnostic devices include Nano biosensors, microarrays, biochips of different elements (DNA, proteins or cells) and lab-on-a-chip devices.

1.3.4. Nano biosensor

A biosensor refers to a measurement system for the detection of an analyte that combine a biological component with a physiochemical detector. Interaction between the compound or microorganism of interest and the recognition element produces a variation in one or more physical-chemical properties (e.g., pH, heat, potential etc.) that are detected by the transducer. The resulting electronic signal indicates the presence of the analyte of interest and its concentration in the sample. These sensors *can be electronically gated to respond to the binding of one molecule. The best part is that biosensors can operate in liquid or gas phase, opening up a wide variety of downstream applications. These detection systems use cheap low-voltage measurement methods and detect binding events directly, so there is no need for expensive, complicated and time-consuming chemical labeling, e.g., with fluorescent dyes, or for bulky and expensive optical detection systems. As a result, these sensors are cheap to manufacture and portable*

1.3.5. Microarrays

Microarrays are a technology in which lots of nucleic acids are bound to a surface and are used to measure the relative concentration of nucleic acid sequences in a mixture with the aid of hybridization and subsequent detection of the hybridization events.

1.3.6. Lab-on-a-Chip

Imagine a small chip in your body that incorporates sample preparation, purification, storage, mixing, detection and other functions, just like what different clinical labs will do, very fascinating right? The chips use a combination of phenomena, including pressure, electroosmosis, electrophoresis and other mechanisms to move samples and reagents through very tiny channels and capillaries, some as small as a rather few dozen nanometers.

Lab-on-a-chip has many applications in medicine and biology. These devices are likely to have a significant socio-economic impact, bringing sophisticated analytical tools to Third World countries, rural areas and resource-poor regions. Advantages of their use include the extremely rapid analysis of samples containing fluid volumes that can be less than a picoliter, the high degree of automation, cost savings due to the low consumption of reagents and samples and their portable and disposable nature

1.3.7. In Vivo Imaging

Unlike classic imaging diagnosis with computed tomography (CT), magnetic resonance imaging (MRI) or ultrasounds, Nano-imaging or molecular imaging includes techniques designed to obtain molecular data to identify the causes of the disease *in vivo* rather than its eventual consequences. Nanotechnology has produced advances in imaging diagnosis, developing novel methods and increasing the resolution and sensitivity of existing techniques. Although these systems have emerging recently and only some of them are in clinical and preclinical use, they have made it possible to study human biochemical processes in different organs *in vivo*, opening up new horizons in instrumental diagnostic medicine.

1.3.8. Drug Delivery

Another important nanotechnology application developed over the past years have been Nano vehicles, nanoscale compounds used as a therapeutic tool and designed to accumulate in the sites of the body where they are needed in order to improve drug therapy outcomes. The main objective of this application is to increase therapeutic effectiveness while obtaining lower toxicity rates. For instance the case of malaria, as soon as you get bitten by a mosquito, there is a Nano medicine there healing you of any possible complications of malaria.

1.3.9 Regenerative Medicine

The purpose of Regenerative medicine to replace tissue or organs that have been damaged by disease, trauma, or congenital issues, as against the current clinical strategy that focuses primarily on treating the symptoms. This is also another part where Nano medicine plays a significant role.

Nano medicine amplify our natural healing process in the places it is needed most, or take over the function of a permanently damaged organ. Regenerative medicine is a relatively new field that brings together professionals in the field of biology, chemistry, engineering, genetics, medicine, robotics, and other fields to find solutions to some of the most challenging medical problems faced by humankind.

2. Conclusion/Summary

Nanotechnology is an emerging interdisciplinary field that combines biology, chemistry and engineering. This will lead to major advances towards individualized medicine, improving the sensitivity and specificity of existing techniques to discover and detect biomarkers and so much more. This would allow earlier and more personalized diagnosis and therapy, improving the effectiveness of drug treatments and reducing side effects. Toeing the path of Nano medicine is never disadvantageous, therefore let us make full use of it to save lives

3. References

1. http://www.mdpi.com/1422-0067/12/5/3303/htm

International Mechatronic Student Micro-Conference

Bánki Donát Faculty of Mechanical &Safety Engineering
Institute of Mechatronics & Vehicle Engineering,
Budapest, 19th of December 2017.

Range Extension with Solar Panel

Tibor Tóth

Work place: Institution (Óbuda Univerity,Donát Bánki Faculty, Mechatronics and Automotive Institute), Adresse: 1081, Hungary, Budapest, Népszinház Street 8, number; Telefon 06706036924, email address: tothtibi100@gmail.com

The spread of electric cars, that are becoming more and more popular, will be an unstoppable alternative to the future of mobility. However, the main barrier to propagation is still the number of charging stations, and the low range. To eliminate the problems, I designed an accessory solar charging system, that adds extra charge to the batteries, both in parking and during the move, and eliminates self-discharge problems.
In our family we have also set up a 4 KW solar system, and it's almost replace the monthly electricity bills, so I started with an optimistic mind for the solar system, and the results are very promising.
In my scientific theoretical research, I will examine how the range of an electric car is affected, with a designed, universally fitting, solar-powered external charging system, that can be activated anywhere in a sunny day, and gives extra energy to the electric car system without warranty loss.
To model the system, I will fit the designed, accessory solar system for the 30 kilowatt-hour Nissan Leaf electric car system, and look at how it works, and how much energy it can add, to the electric car's batteries in theory. In my calculations, I took into account the urban conditions, the battery charge characteristics, the angle, and the losses. I have succeeded in creating an ideal and practical model that is pessimistic enough, to reflect or exceed the reality. To make the model, I called for the Solar PV database, which is a good point to deliver an ideal performance calculation or energy yield up to day. The information was collected and represented by Excel, and the data was graphically evaluated. I was thinking about the security requirements and accessories that are essential to building the system. As the car has a maximum of 1 solar panel, it is essential to choose the right components for a designed a productive system. Since I did the cost calculation in the theoretical experiment, we will also get a payback period. However, starting from households, it is almost 10 years away, so the system is more be practical and convenient, instead of the function of producing money. As an electric car is forced to connect to a power outlet, these few kilometers can be a lifesaver for the driver, which is provided by this simple auxiliary system. When solving problems, I took into account the low maintenance costs, but also the respect of the right quality. Since at the beginning of my thesis I did not have this kind of solar system in market, and only with a similar approach from the autumn, a Toyota Prius PHEV get this solution with extra charge of 900,000 forints, so I ended up with the differences between the two systems. Since my system produces nearly two times, and it cost less than 75% of the Toyota solution, I think my implementation could be a better solution, and more, it can be fitted to any electric car.

3. MODELLING/DESIGN

To make the Electric Vehicles more widespread, I created a functional accessory for these cars. For the representation, I will use the Nissan Leaf 30 kWh, 2014-year model, because it has enough documentation and information for public, to build a suitable Charging Circuit for this car. First, I need to choose the components, which are suitable for the Nissan Leaf car. The three main components will charge the Lithium-Ion battery, and the 12 V acid battery, to extend the factory range with many miles. This method, a solution for the charge loss during in steady stay, also charge the main battery and serve also the electrical consumers during the drive. To choose the most suitable Solar Panel, Solar Modul and cables, we need to figure out the space we have in the roof. The Nissan Leaf has enough big roof for a 1-meter wide, and 2-meter long solar cell module.

3.1.1 Nissan leaf 2014 Hatchback dimensions [20]

1.1 Choosing the components

In the roof of the car, we need to place the Solar panel with use of the factory fixed points. The 4 screws will hold the Solar panel to the roof. We have to think about the air dynamic factor, that it be get worst, but in fact that the panel thicker than 5 centimeters, it doesn't get on focus to calculate with this. As the Electric car is used at in the city, where the maximum speed limit is 50km/h, the panel on the roof don't count as much. It counts at 70km/h where the air flow is get bigger.

To take place the wiring of the solar panel, I will use the car radio antenna hole to isolate and hide the wires from the external circumstances. Instead of the car antenna, I will use an amplified inner take antenna, to substitute the factory antenna without any loss.

Inside the vehicle a Solar Modulator needed to convert and manage the electricity coming from the Solar Panel. In case of we need AC voltage for the Lithium-Ion battery charging (factory charging with the plug in), and DC for the additional 12V battery, two types of modulator needed. Of course, the two modulators can't run together, because it won't run efficiently, and of course during parking, there is no need to charge the 12V battery.

The idea is that, the two modulators will run differently, one time run only one. A power switcher will use to decide manually, what shall the car use. For the maximum efficient, when the car running, the DC modulator needed, and when the car is park the AC modulator must be used. In this case the Solar Panel will work all day. Of course, in a total dark area, where there is no community light on the road, the charging can't run properly, or even not work.

To choose the right components for the project, we need to mind that, this system only an equipment for a car, so it need to be cheap to widespread. Today an electric car is about 30.000$, so the costs need to be under the total of 3%. For my project I wanted to spend 750$, and show that it is a wort to invest it. System building don't need too much experience or skill, so that's also help this accessory to be successful.

We need to care the safety instructions also. The components required, extra durability against the weather, must be stealing proof, and easy to replace, if accident or upgrading happened.
To sufficient all these facts I need to find reliable manufacturers, for these standards. Only the right components need to be choose. In the following article I will introduce my personal device choices, and explain it why I wanted to build in my Nissan Leaf model. The most important component in my system is the Solar panel. The efficient is mostly based on this, so I find a good product of it:

3.1.2 LG375N2W-G4 NeON2 72 [21]

The reason of choosing the Monocrystalline n-type LG 375 W Solar panel XL LG375N2W-G4 NeON2 72 cell product is the following: 25 years warranty, better performance on a sunny day, high power output, doubled-sided cell structure, balance of system saving. Compared these facts the LG seems to be the best value/price product. Total cost of a panel is around 520 $, ~ 150,000 HUF. The panel efficient is 19.1%, which is a good number. There is also Chinese Manufacturers, which are have the same product with lower price, but the warranty and the durability is more important, than the cost. We can see under the chosen solar panel specs (LG 375N2W-G4)

LG NeON 2 72cell

LG375N2W-G4 | LG370N2W-G4 | LG365N2W-G4

Mechanical Properties

Cells	6 x 12
Cell Vendor	LG
Cell Type	Monocrystalline / N-type
Cell Dimensions	156.75 x 156.75 mm / 6 inches
# of Busbar	12 (Multi Wire Busbar)
Dimensions (L x W x H)	1960 x 1000 x 46 mm
Front Load	5400 Pa
Rear Load	2400 Pa
Weight	20.3 ± 0.5 kg
Connector Type	MC4
Junction Box	IP67 with 3 Bypass Diodes
Length of Cables	1200 mm x 2 ea
Glass	High Transmission Tempered Glass
Frame	Anodized Aluminum

Certifications and Warranty

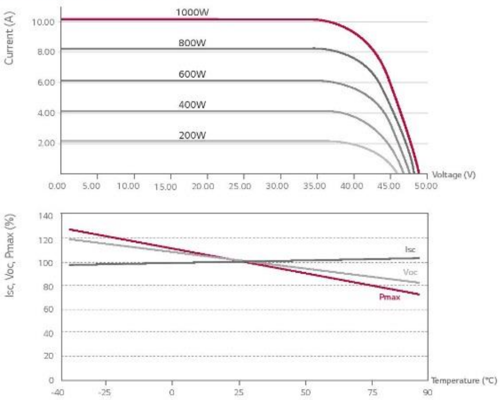
Certifications	IEC 61215, IEC 61730-1/-2
	UL1703
	IEC 61701 (Salt corrosion test)*
	IEC 62716 (Ammonia corrosion test)*
	ISO 9001
Module Fire Performance	Type 2 (UL1703)
Fire Rating (for CANADA)	Class C (ULC/ORD C1703)
Product Warranty	12 years
Output Warranty of Pmax	Linear warranty**

* in progress
**1) 1st year: 98%, 2) After 2nd year : 0.6%p annual degradation, 3) 83.6% for 25 years

Temperature Characteristics

NOCT	45 ± 3 °C
Pmpp	-0.38 %/°C
Voc	-0.28 %/°C
Isc	0.03 %/°C

Characteristic Curves



Electrical Properties (STC *)

Module Type	375W	370 W	365 W
MPP Voltage (Vmpp)	39.6	39.2	38.9
MPP Current (Impp)	9.50	9.44	9.39
Open Circuit Voltage (Voc)	48.3	48.0	47.7
Short Circuit Current (Isc)	10.04	9.98	9.92
Module Efficiency (%)	19.1	18.9	18.6
Operating Temperature (°C)		-40 ~ +90	
Maximum System Voltage (V)		1000	
Maximum Series Fuse Rating (A)		20	
Power Tolerance (%)		0 ~ +3	

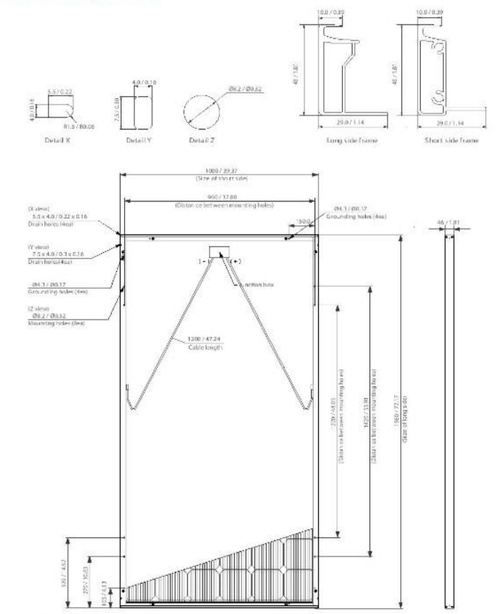
* STC (Standard Test Condition): Irradiance 1000 W/m², Module Temperature 25 °C, AM 1.5
* The nameplate power output is measured and determined by LG Electronics at its sole and absolute discretion.

Electrical Properties (NOCT*)

Module Type	375 W	370 W	365 W
Maximum Power (Pmax)	277	273	269
MPP Voltage (Vmpp)	36.6	36.3	36.0
MPP Current (Impp)	7.57	7.52	7.48
Open Circuit Voltage (Voc)	45.0	44.7	44.4
Short Circuit Current (Isc)	8.08	8.03	7.98

* NOCT (Nominal Operating Cell Temperature): Irradiance 800 W/m², ambient temperature 20 °C, wind speed 1 m/s

Dimensions (mm/in)



* The distance between the center of the mounting/grounding holes.

LG Life's Good

North America Solar Business Team
LG Electronics U.S.A. Inc
1000 Sylvan Ave, Englewood Cliffs, NJ 07632

Contact: lg.solar@lge.com
www.lgsolarusa.com

Product specifications are subject to change without notice.

Innovation for a Better Life

3.1.3 Solar panel specs, datasheet [22]

We can see that the properties are showing great result of this solar panel. The maximum power is 375W per hour, which means that, in an ideal sunny day, at worktime, a 10 hours long parking enough to charge around 10 percentage of a 30 kWh Li-ion battery packed Nissan Leaf, which is enough to run 15km for free.

This matter a lot, when you park a place where is no electricity, and you don't have to worry about to get to the next station where you can charge your car. This is a good solution for those, who live the nearby from their workplace.The other good think about this Solar product: The reliability: LG makes good solar panels, and a well know manufacturer. The datasheets allow enough data to design the structure, but not only we need the Solar panel. We need also great Solar modulators to maintain the efficient, and made the system for decades. These Inverters hopefully work in a great efficient, nearly at 98%, so we have the possibility to choose the best for the Solar Cell. We need to choose two Inverter one for the main battery charge, so DC to AC converter, and one for the small 12V acid battery, DC to DC inverter needed. First of all, the manufacturer recommended to use only Solar Microinverters, so chosen the Smart Grid Ready Emphase IQ 6+ Microinverter which is also on the list of compatible devices.This inverter works on a wide area, compared to another similar product. for a bonus it has smart control, and in the CAN-bus system it can communicate with other devices.The Manufacturer provides home and industrial solutions of a hole Solar system build, so it has enough reference to make this product reliable. This transformer has Smart Voltage control, which allows to connect several types, 60 or 72 Cell of Solar Modules.
This great future allows to use different Solar panels in the future, and made this product widespread. The price is about 140$ so with the Solar Panel, the total cost is around 300$. Only the wires, and another DC inverter needed for the project. The datasheet is the followings:

3.1.4
The


Data Sheet
Enphase Microinverters

Enphase IQ 6 and IQ 6+ Microinverters

Designed for higher powered modules, the smart grid-ready Enphase IQ 6 Micro™ and Enphase IQ 6+ Micro™ are built on the sixth-generation platform and achieve the highest efficiency for module-level power electronics and reduced cost per watt.

Part of the Enphase IQ System, the IQ 6 and IQ 6+ Micro integrate seamlessly with the Enphase IQ Envoy™, Enphase IQ Battery™, and the Enphase Enlighten™ monitoring and analysis software.

The IQ 6 and IQ 6+ Micro are very reliable as they have fewer parts and undergo over 1 million hours of testing. Enphase provides an industry leading warranty of up to 25 years.

Easy to Install
- Lightweight
- Simple cable management
- Built-in rapid shutdown (NEC 2014)

Productive
- Optimized for high powered modules
- Supports 60 and 72-cell modules
- Maximizes energy production

Smart Grid Ready
- Complies with fixed power factor, voltage and frequency ride-through requirements
- Remotely updates to respond to changing grid requirements
- Configurable for varying grid profiles

To learn more about Enphase offerings, visit **enphase.com**

ENPHASE.

Emphase IQ 6+ Outlook [23]

INPUT DATA (DC)	IQ6PLUS-72-2-US AND IQ6PLUS-72-5-US	
Commonly used module pairings[1]	235 W - 400 W +	
Module compatibility	60-cell and 72-cell PV modules	
Maximum input DC voltage	62 V	
Peak power tracking voltage	27 V - 45 V	
Operating range	16 V - 62 V	
Min/Max start voltage	22 V / 62 V	
Max DC short circuit current (module Isc)	15 A	
Overvoltage class DC port	II	
DC port backfeed under single fault	0 A	
PV array configuration	1 x 1 ungrounded array; No additional DC side p AC side protection requires max 20A per branch	
OUTPUT DATA (AC)	**IQ6PLUS-72-2-US AND IQ6PLUS-72-5-US**	
Peak output power	290 VA	
Maximum continuous output power	280 VA	
Nominal voltage/range[2]	240 V / 211-264 V	208 V (1Φ) / 183-229 V
Nominal output current	1.17 A	1.35 A
Nominal frequency	60 Hz	
Extended frequency range	47 - 68 Hz	
Power factor at rated power	1.0	
Maximum units per 20 A branch circuit	13 (240 VAC) 11 (single-phase 208 VAC)	
Overvoltage class AC port	III	
AC port backfeed under single fault	0 A	
Power factor (adjustable)	0.7 leading ... 0.7 lagging	
EFFICIENCY	**@240 V**	**@208 V (1Φ)**
CEC weighted efficiency	97.0 %	96.5 %
MECHANICAL DATA		
Ambient temperature range	-40°C to +65°C	
Relative humidity range	4% to 100% (condensing)	
Connector type	MC4 or Amphenol H4 UTX	
Dimensions (WxHxD)	219 mm x 191 mm x 37.9 mm (without bracket)	
Weight	1.5 kg (3.3 lbs)	
Cooling	Natural convection - No fans	
Approved for wet locations	Yes	
Pollution degree	PD3	
Environmental category / UV exposure rating	Outdoor - NEMA 250, type 6 (IP67)	
FEATURES		
Communication	Power line	
Monitoring	Enlighten Manager and MyEnlighten monitoring Compatible with Enphase IQ Envoy	
Compliance	UL 62109-1, UL1741/IEEE1547, FCC Part 15 Clas CAN/CSA-C22.2 NO. 107.1-01 This product is UL Listed as PV Rapid Shut Dow NEC-2017 section 690.12 and C22.1-2015 Rule 6 and DC conductors, when installed according m	

3.1.5 The Emphase IQ 6+ EU Datasheet [24]

The specifications are convincing, The DC-AC inverter can run around 97% efficient, so that transport enough power to charge the 400V Lithium-Ion Battery. The Inverter produce AC 240 V power, So it mostly suitable for Europe standard. We done with the choosing of the main inverter, but remains the additional DC-DC Inverter, because the Emphase IQ 6+ is only charge, when the car is on rest or parking, when the charging cable plugged on.

To take advantage of the power which is produced by the Solar Panel when the car is moving, we need a smart, self-controlled DC-DC converter for the 12V acid battery. We need to be mind that, the battery we charge is a common 12V 75Ah car acid battery. So we need nearly 14V and nearly 20Amps to help the DC-DC controller. We can wire directly for the Battery whit a diode, so it doesn't matter is the DC-DC converter work or not, because it smart enough to manage the Voltage and Current on the acid 12V battery, so it will save energy if we add an external supply. And we have nearly 40V and 9 Amps roughly produced by The LG Solar Panel, it's needed to be convert to 13.7V and as many Amps as possible. The 13.7V is a safety Voltage of charging, due to the Battery life. For this, there is a very good product, it has the best Value/ Price factor, so I found the: Delta B62SR13722 B type 300W Inverter.This will supply the Acid battery with the fixed 13.7V, and maximum 22Amps to reduce energy usage during the trip.

B40SR/B62SR/B70SR Series

FEATURES

Electrical

- Ultra wide input voltage range 18~106V
- Intergrated fuse holder (optional)
- Parallel connection of multiple units
- Operating temperature range -40°C to +75°C
- Minimized inrush current
- Input reverse polarity protection
- OTP, input UVLO, output OCL, SCP, OVP
- Enable on/off (option)
- Isolation voltage 2250VDC

Mechanical

- Box type package with metal base plate
- Package dimension: 190x76x44mm
- IP67 protection

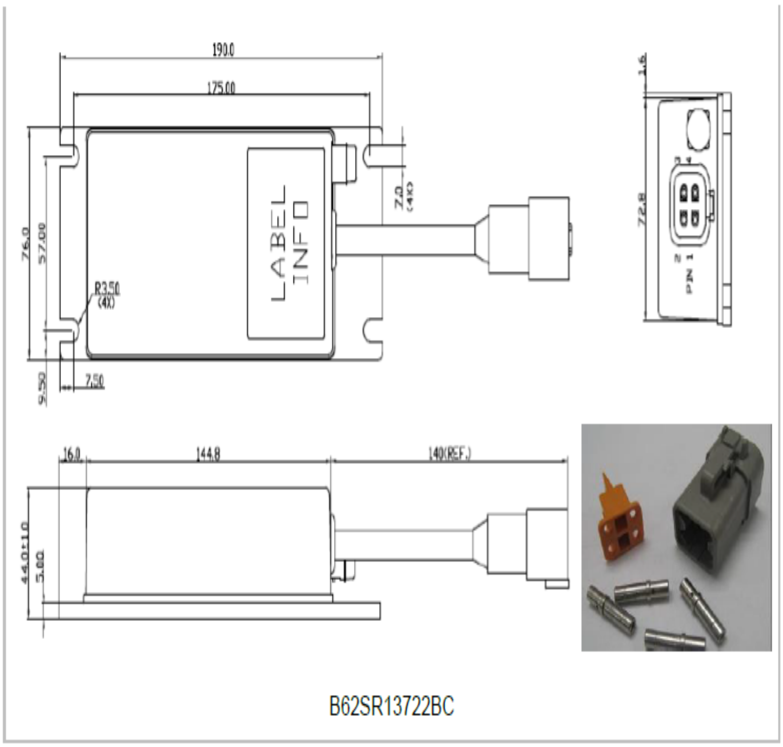
Safety & Reliability

- UL 60950-1 & CSA C22.2 No.60950-1-07
- IEC/EN 60950-1

SPECIFICATIONS

Part Number	Input Voltage	Output Voltage	Output Current	Output Power	Efficiency
B40SR12424DP	18~60V	12.4V	24A	300W	88.3%
B40SR12424A/B/C/D	18~60V	12.4V	24A	200W @18~27Vin 300W @27~60Vin	88.3%
B40SR13722A/B/C/D	18~60V	13.7V	22A		88.5%
B62SR12424A/B/C/D	18~106V	12.4V	24A	200W @18~27Vin 300W @27~106Vin	88.0%
B62SR13722A/B/C/D	18~106V	13.7V	22A		88.5%
B62SR24125A/B/C/D	18~106V	24V	12.5A		91.0%

3.1.6 Specific label of B40SR13722 B type Inverter [25]



Pin	Function Description
1	OUTPUT -
2	OUTPUT +
3	INPUT -
4	INPUT +

- All dimensions in mm (inches)
- Tolerance:X.X±0.5 (X.XX±0.02)
  X.XX±0.25 (X.XXX±0.010)
- Connector:
  Deutsch DTP Receptacles
  (DEUTSCH P/N :DTP04-4P)
- Connector kit :
  Housing: DTP06-4S
  Wedge lock: WP-4S
  Terminal: 0462-203-12141

3.1.7

Specific drawing of B40SR13722 B Type Inverter [26]

Compare to another Inverters, this have a stable 13.7V output, Small Size, and cost less than 10 Dollars, so it's easy to replace, due to the fast Connector kit. The efficient is nearly 90%, but mind that it's work in a wide range in area (18-106V). The fuse also in the housing so we don't need to care about protection.

The connection is Deutsch head, so its IP 67 protected, and if its needed, it easy to replace it. Finally, we also need wires and clips to connect the inverter to the battery. The wires also can use for the DC-AC Emphase Inverter and for the DC-DC BSR series. Only the Diodes and the AC Connector remain, to made the system safe, and easy to use. For the wires, after long time research, I decided to use car hi-fi power cables, for several reasons. This cable is width enough to supply all Inverters and don't get hot, even a long time usage, very flexible, so when we build the system it can easy to use, and it's easy to get from the shop.

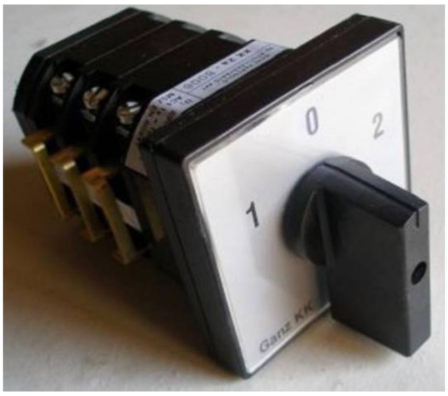
We can add also extra fuse easily, if it's needed. We need at least 14 meters cable, I found with the same diameters, but we need different colors to see the different pole. So 7meter red and 7 meters black need to be purchase. We need 1.5meter red and 1.5meter black cable for the DC-AC inverter (Emphase IQ6+) and AC plug connection. The diameter is 10 mm2, so it can transport energy without any loss, and overheat. According my previous experience, I prefer this cable, because easy to use, have enough connector clippers, and fuses on the market to connect any kind of system to it.

3.1.8 Hi-fi Red Positive + cable and Hi-fi Black Ground – cable [27]

The CONNECTION PF 8BK.2 is a black, flexible cable, and the CONNECTION PF 8OR.2 is a red or orange cable. Each cable is the same, but have different color cover. For the DC-AC inverter we need only 1.5 meter from each, because the Inverter behind the back seat, and we only need to connect with a commercial AC plug.
The remaining 5.5 m long red cable and 5.5m black cable can be used to connect the DC-DC (BSR series) converter with the 12V acid battery. Each cable cost 990 HUF/meter, which is around~3,5 $. The clips, nuts and screws remain to get tighten and fix the components. As the cables capable to transport high energy as the Hi-fi-technology needs, I will use also the suitable accessories for it.
The clips and nuts also can bough with the cables, even in a kit. The nuts and clips will cost at max 10 dollars, which enough for 10 connections.
To make the system more practical to use, I would like to install a 220V and 16-Amper AC Plug in to the luggage rack of the car. At there, it will be easy to use the original charging accessory for the car. The original charger of the car, can easily fit in to the plug.

3.2 Industrial AC plug in [28]

This makes the whole system safe, and easy to use. The reason why I find suitable switch component for the system is simple, it is easy to install and use. I also would like to have a three stage, safety main switch to change between the functions: 0, OFF- when there is no charge, 1 when the DC-DC charger charge the secondary 12V acid battery, and the 2 positions when we can charge the main battery in stay. It is also resist high voltage .and prevent sparking, when we would like to switch between the stages. It is very important fact when we wanted our system safe, because sparking can be dangerous for the components, and it’s also a possible fact to. It is easy to install in a box, to make it water and dust resistant. The Switch is designed for 400V and 20A, DC.



3.1.9 An Industrial Ganz KK-0-20-6008 switch with three positions [29]

A Safety Fuse also remain to protect the system, it seems to be a good idea to searching the right component again in the field of the car audio market. I wanted a water proof box, and at least three fuse spaces inside the component. The DLD 4004 seemed to be good for this. It has also a good price as well and good for distributive function. We can also use different kind of fuses, for now I will Use a 2,5-Amper fuse, and designed for 230 V, to save the inverter.

3.2 Fuse Holder /distributive manifold DLD 4004 and Voltage meter [30,31]

Last component is the Voltage meter. To be sure how much power is produced by the solar system. It is also functioned as an indicator, to be sure we park at a sunny place, or it is wort to take on the solar system.
The operating range between 0-100 Volts and 0-20 Amps.
If the Voltage more than 16V we can charge the main battery, and if it greater than 12V, we can charge the acid battery sufficiently.

3.2 Cost Calculation

The Components are ready to build, but what about the costs?
For that I made an excel table to follow all the costs, and investments.

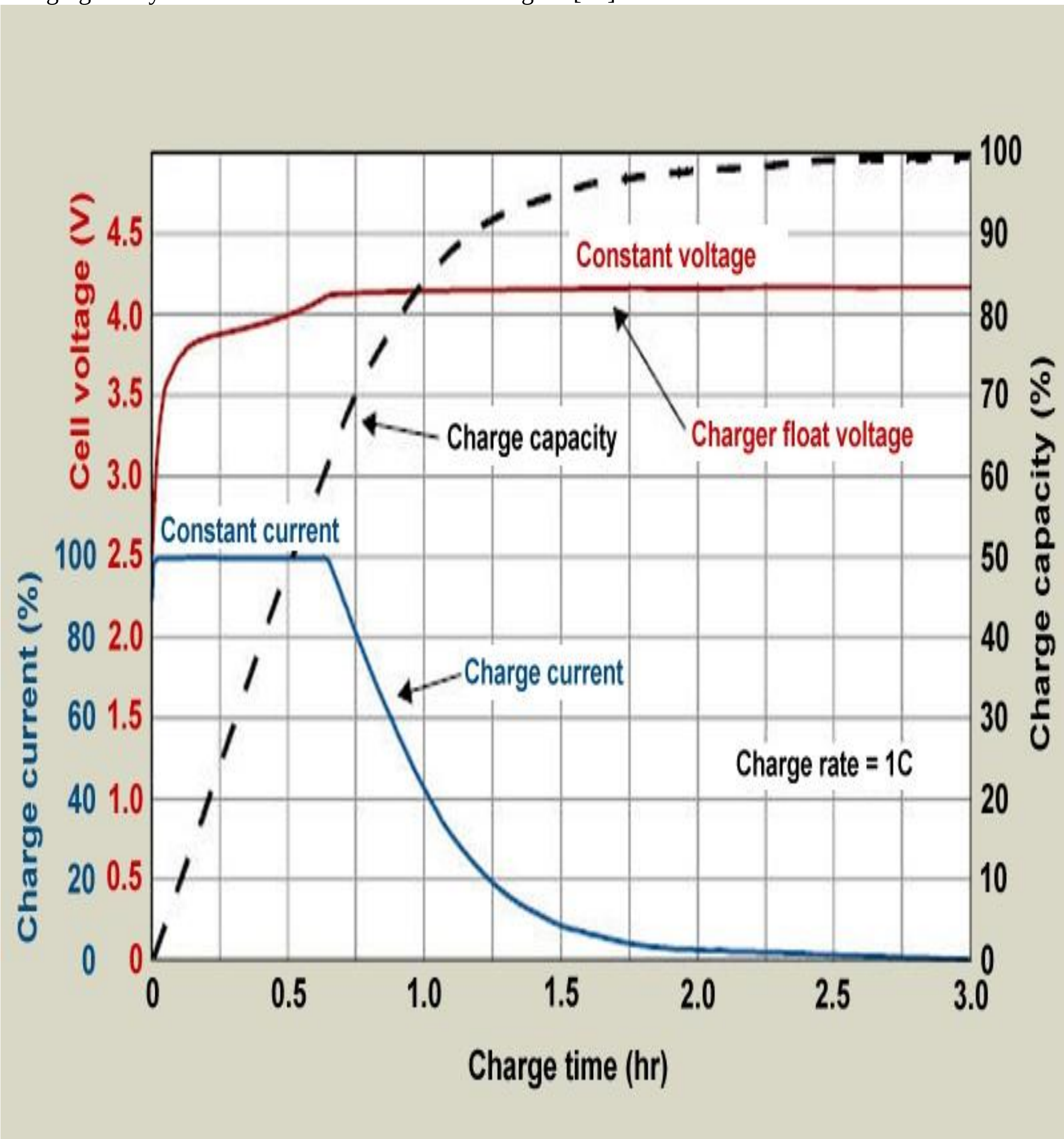
Products:	Cost USD with tax	Cost in HUF with tax
Nissan Leaf 2017 30kWh	36 551,72 $	10 600 000 Ft
Solar Panel Lg neon2 375W	517,24 $	150 000 Ft
Solar Inverter DC-AC IQ+ EU	140,00 $	40 600 Ft
Solar Inverter DC-DC BS150	9,24 $	2 680 Ft
Cables 10mm Hifi	39,66 $	11 500 Ft
AC Plug	1,88 $	546 Ft
Clips Hifi cables	10,34 $	3 000 Ft
Industrial Switch Ganz KK	20,63 $	5 982 Ft
Industrial Fuse DLD 4004	8,97 $	2 600 Ft
Voltagemeter	10,31 $	2990Ft
Total	309,44$	10 819 768,10 Ft
Cost of the system	757,96$	219 898 Ft
Cost of the System, compare to the car value (in %)		2,075%

USA Dollar	HUF
1	290

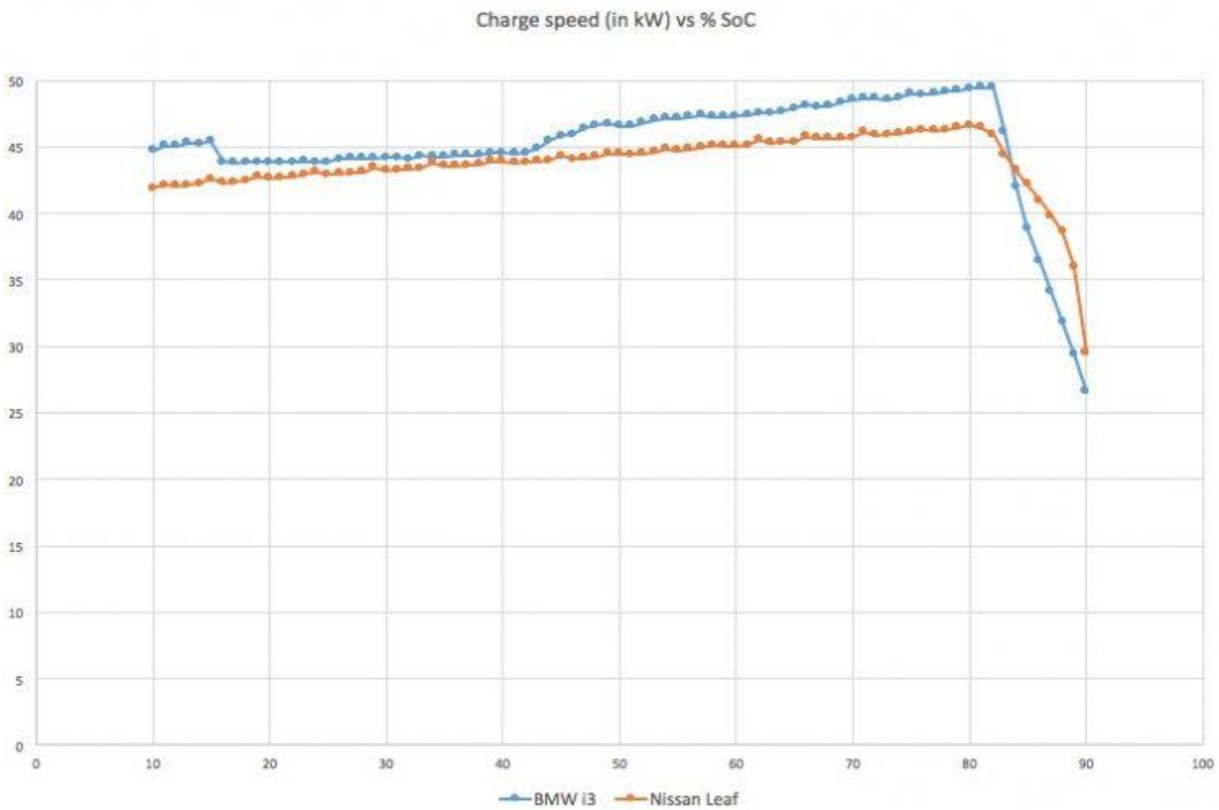
3.2.1Costs [32]

As we can see, the total system cost nearly 2% of the car value. This investment not so much, as we can recognize 4 new tire costs nearly the same. But what about the cost of a charge?
As we know, the battery charging is not constant, I will investigate only the range of the capacity of 10% to 80%, to simplify the calculations. In this range (10%-80%) nearly the charging is constant. For fast charging, mostly the same effect takes place.

The charging nearly constant between 10% and 80%. figure [33]



3.2.2 Lithium ion charging characteristic [33]



3.2.3 Fast charging characteristic (46-80% in 14 minutes) 30 kWh Nissan Leaf compare with the 33kWh BMW I3 [34]

As we can see the charging is nearly constant at the range of 10% and 80% of the battery capacity. So, to be clearly look I will investigate this range on the followings, to take a clear look how the charging costs and time looks like.

The Nissan manufacturer be sure that from a common domestic plug (which designed for 220 Volts and 10-Amper) can charge the main battery less than 12 hours from zero to 100%, But the fact that it is losses also. The owners said it 15 hours at least need to charge for a full empty "tank". With the losses (8-13%) I calculated with an optimistic 10%. To be clear I calculate with 11 hours from 10% to 80%, battery from the start and the end it need more time than the other sectors to charge. For the representation, I created an excel table to see, how the battery juice goes, after the hours.

To perform a more realistic model, we need to think about the real Kilowatt watt hours available in the car. The catalog said 30kWh battery available, but in real only 25-27 kWh is capable. The reason is the tolerance and the temperature mostly. In cold circumstances the battery, stores less power than in ideal, around 20degree of Celsius.

To show how much does it cost to recharge an electric car from the domestic household electricity/plug (2.2 kWh 10 Amps), I created a table, to show that. The data based on the manufacturer webpage. It said that, it's need 15 hours to charge from a 0 % battery to 100%.

As previous I mentioned, to make an easy model, I focus only from the range between of 10%- 80% of the battery storage. I calculate with a very ideal model, when a constant charging happening, from 10% to 80%, and the solar panel and inverter produce constant power for 11 hours. This is only for modeling, and compare the domestic plug and the solar panel efficient and cost. I created an excel to represent the kilometers and cost, and charging hours.

First, I calculated with the common domestic plug at home. At home there is 220V 16-Ampers, but the manufacturer said the electric car charger is designed for 220Volts and 10-Ampers, for safety reasons. It's commonly know that, system losses are everywhere, so the input is never the same as the output. That's why I calculate whit a nearly 10% loss, and add only 2 kWh every hour, to the battery.

As electric car owners know, we discuss with kWh / 100 km, rather than Liter / 100km.
A leaf is consuming nearly 13kWh / 100km, and its range with a normal usage (using Air conditioning, multimedia, and drive multifunctional) can run around 200 km. That's why 2 times 13 kWh nearly the capacity of the battery.

One charge cost around 1200 Huf ~ 4$, compare with the diesel or gasoline per liter is quite cheap to run. But electricity is not in everywhere, so in an ideal situation, we compare the domestic plug in, and the solar panel solution, which is charge more or less.

The chart below shows that around 11-hours we add 140 kilometers range for the car, fill 22 kWh to the battery, and boost up the battery to 80% from 10%.

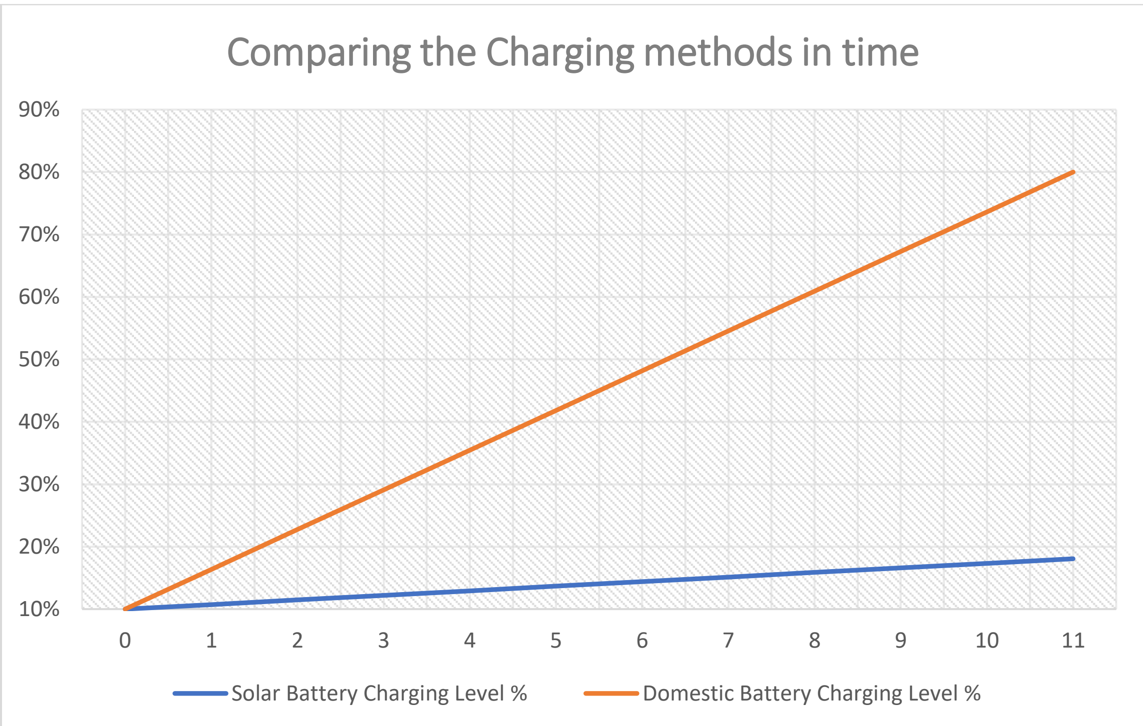
Hours	Watt Domestic Plug in		Costs Huf	Battery Charging Level %	Km added
0,00	3000,00	Watt	0,00	10,000%	20,00
1,00	5000,00	Watt	80,00	16,364%	32,73
2,00	7000,00	Watt	160,00	22,728%	45,46
3,00	9000,00	Watt	240,00	29,091%	58,18
4,00	11000,00	Watt	320,00	35,455%	70,91
5,00	13000,00	Watt	400,00	41,819%	83,64
6,00	15000,00	Watt	480,00	48,183%	96,37
7,00	17000,00	Watt	560,00	54,546%	109,09
8,00	19000,00	Watt	640,00	60,910%	121,82
9,00	21000,00	Watt	720,00	67,274%	134,55
10,00	23000,00	Watt	800,00	73,638%	147,28
11,00	25000,00	Watt	880,00	80,001%	160,00
15,00	30000,00	Watt	1200,00	100,00	200,00
Added KM from charging					140,00
km added of a full charge in %	22000,00				70,00%
	200,00				
Days needed to Charge	0,63				
Hours Needed to Charge	15,00				
Costs Sum / Charge	1200,00	Huf			
kWh Batt	30000,00	Wh			
Ac Power Watt (220V ,10A) with 10% losses		2000,00	Watt		
Cost Per kWh		40,00	Huf		

3.2.4. Ac Power plug calculation [35]

Of course, this is an ideal, but pessimistic solution with less heat generated, and with a constant charge. But to represent the differences we need to create this model. to see the differences from the solar charge, list the chart below. I calculated with the guaranteed 277W, and with the losses.

Hours	Watts with Solar		Solar Battery Charging Level %	Km added
0,00	3000,00	Watt	10,000%	20,00
1,00	3219,94	Watt	10,733%	21,47
2,00	3439,88	Watt	11,466%	22,93
3,00	3659,81	Watt	12,199%	24,40
4,00	3879,75	Watt	12,933%	25,87
5,00	4099,69	Watt	13,666%	27,33
6,00	4319,63	Watt	14,399%	28,80
7,00	4539,57	Watt	15,132%	30,26
8,00	4759,50	Watt	15,865%	31,73
9,00	4979,44	Watt	16,598%	33,20
10,00	5199,38	Watt	17,331%	34,66
11,00	5419,32	Watt	18,064%	36,13
	Charged %		km added	16,13
	2419,32	watt pumped		8,064%
15,00	6299,07	Watt	21,00	
	Free electricity cost			
	96,77	Huf		
	Peak power of Solar (W)		277,00	
	Inverter efficient 16V-35V		97,00%	
	Solar power Watt/hour Ideal with losses		219,94	Watt
	Days to 100%		8,68	
	Hours to 100%		208,33	
	20,60%	% sum losses		
	payback after the number of charges			2265,80
	Total System cost		219268,00	Huf

3.2.5 Solar Panel Calculation [36]

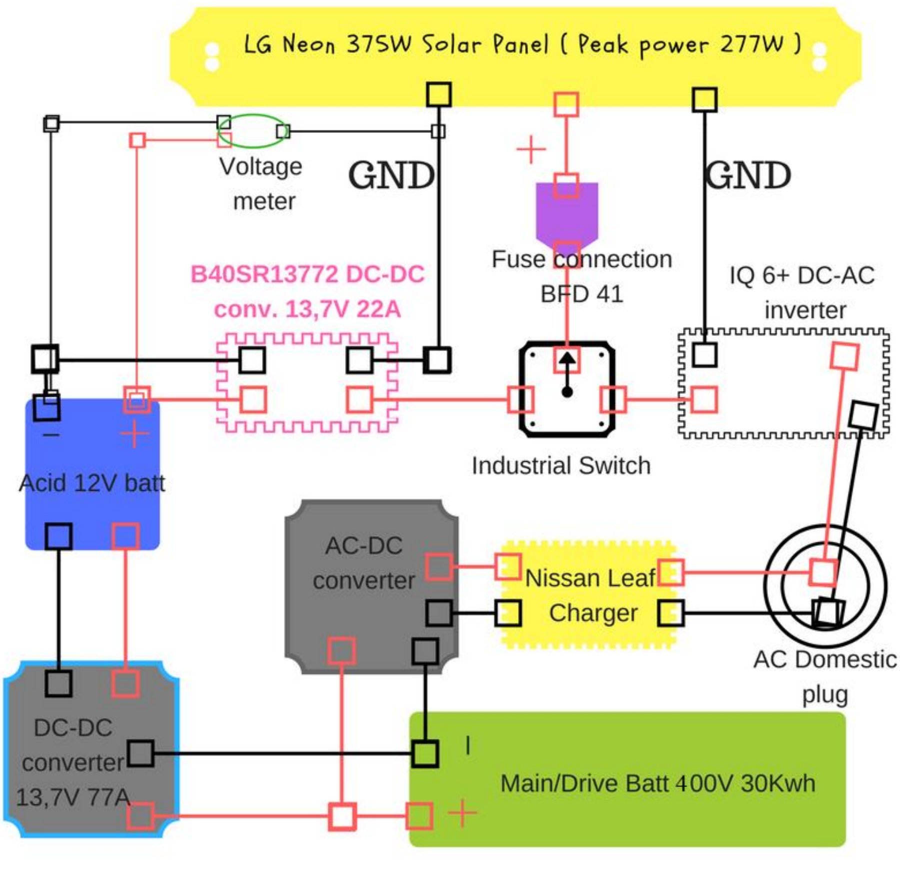


3.2.6 Compare Ideal Charging methods [37]

In a graphical view, we see the difference, of the charging solutions. In the horizontal line the Time in Hours, and in the Vertical the Battery Charge in percentage (%). We find big difference of course. With the model of a very sunny, cloudless and nice day, with nearly constant 20 Celsius degree, we can create the upper model for calculation. With the losses the inverter produced nearly 220 W / hour.
We can summarize that, its nearly the one-tenth of the production of the domestic plug. It only added 16,13 km to the range and juice up with 8,064 % of the battery. Not so much, but it’s free. We earn nearly 100 forints (exactly 96,77 HUF) of electricity, and we can use in every sunny place.
And of course, need also more than 10 times to charge up the battery, compare to the domestic plug, but at least, it’s free and sun is available mostly everywhere.
The previous calculation, was an ideal model, in a very sunny area, and that model is good for showing the maximum performance of the system. As previous mentioned, I discuss with the Hungarian condition, especially with the city circumstances, because mostly people use here electric cars, according to their benefits. On the following terms, I will explain how the system built up, how it works, and according to the Solar database, how much electricity can produce the system in Budapest. Later I will make a conclusion of the usage, and the benefits of the system. I will also talk about the safety regulations, why the fuses needed, and why I used hi-fi car cable instead of the commonly known cables. The payback or return time is around 2267 charge if we calculate with the upper model. This is more than 20 years. Bur not the return is the main fact in this investment, mostly the usage is more important. It cost around 220 thousand forints, and we don’t need to care when we park in a sunny area somewhere for days, and the battery drained out when we get back our car. Of course, if we leave with a charged state. We also can extend our range when we drive, with using the lights and comfort equipment, the drive battery doesn’t lose too much energy, because it is also supplied from the solar panel.

4. BUILDING THE SYSTEM

As all the components are ready to use, we can build the system ready to use. In the Design part I fully mentioned why I choose the right component. To explain how the system will work, I created a sematic figure.



4.1.1 Sematic figure of the system [38]

In the figure we can see that, we need to separate the ground from the chassis system by safety reasons. That’s why we need at least 14 meters of hi-fi cable, and the flexibility is needed to build in the car properly.

The solar Panel is fixed to the packing holder console to the roof by the screws which is given to the panel. To avoid guarantee loss, we use the Nissan leaf charger when we in the parking mode and charge with the solar panel. It is needed to clear that, it is not necessary to use the solar system when we charge from the domestic or any kind of electricity.

Theoretically, if we use the solar system in any stage (1 or 2) we don't have any issue, the system is protected, and the inverter also smart enough, when sort circuit happened, it turns off.

The Building is simple. If we follow the sematic figure, we can easy install the system around 2 hours. First of all, we need to clear the root of the cables, this is a bit IP panel and carpet work. We have simplified situation when the vehicle is equipped with a car hi-fi amplifier.

We just need to connect to the cables, and we reach the 12V acid battery. Instead of we don't have any kind of system like that, we can reach the 12V acid battery easily, we need to find a way for the cables to under the bolster.

This need at least 1 hour. Than in the back of the car we need to install the inverters. and connect the cables. Install the domestic plug, and install the Voltage meter near the driver seat. We need a separate 12V and a 12V ground to measure the voltage between than range of 0 and 100V.

We need to connect the voltage meter measuring cable to the solar panel ground cable. If the voltage is more than 16 V, our system is producing measurable power for the batteries. This 16V is the critical voltage for the inverter.

The IQ6+ need 16V to be productive and work around the efficient of 80%. The BSL converter at least need 18V-27 V to produce 200W output. If in the solar panels more than 27V flow, it can productive on 300W output.

After the inverters and all the cables in place we need to install the fuse holder and the industrial switch. It is important to install the Solar panel at least, because it produce electricity constantly and it cannot be turned off.

If we sure about the system in 0 position we can connect, the solar panel. We instantly see a voltage drop on the Voltage meter, this is called the open circuit voltage.

Current doesn't flow in an open circuit, only when a consumer is in the circuit. With the Voltage meter, we can see that is it worth to turn on the solar system or not. We need to reach the critical 16 Volts to be productive for the inverters.

4.1 Solution Explanation.

As I build a universal system for any electric car, the work of the system is very simple. In a sunny day we see the Voltage meter, and if it goes more than 16 Volts, the system produce energy for our car. This is the voltage, where the inverter can work, and generate electricity for the main battery.
This will be the 2nd stage on the industrial switch, and we need to plug the domestic charger into the inverter, and for the car. This means, of course we need any time this official domestic charger, but anyway, an average electric car owner also used in everywhere, so it's a must to get with us. It's important that this procedure can only happened at a parking stage, when the car in a stay, and in a sunny place.
The 1st stage on the industrial switch will activate the DC-DC converter, but for it, at least 18 Volts needed. The motor can also run, and when it used, it's suppled the 12V acid battery, needed less energy from the drive battery, and remain more for the ride.
The 0 Stage turn off the system, and deactivate all the components. A fuse box protects the system for internal, and external voltage and current errors.
The LG Solar Panel is a so called optimized module, with three integrated optimization modules. This means, this three-little circuit in a solar panel, can prevent significant performance loss in shady situation in each panel. This means, when a little shadow appears any part of the solar panel, this arrayed circuit prevent voltage drop for the other block of cells.The theory is the following: When a shadow drops the production of any cell or array of cell, the micro optimizer turns off the solar array, which under shadow, preventing to lose energy by the law of the "weakest". This means, solar blocks work as a main big solar panel, and the weakest point pulls back the production. As, an example : if in the 4 cylinder engine 1 cylinder not working, the performance is drops, more

than if only the 3 cylinder run, because it is pull back the performance as the 1 wrong cylinder need to be run. Same thing happens here.
The inverter collected the produced energy from the Solar Panel. The Solar Panel produce DC current, and the inverter convert it to AC Current with transistors, and we can reach in the back of the car with the domestic plug. We need to plug in, the commercial electric car charger, and connect to the charger plug.
If we have enough, power produced by the Solar Panel, the inverter starts working, and we can charge our electric car. If we want to use our solar system during drive, we can switch the industrial switch to the 1st mode, to activate the DC-DC converter.
This will charge the 12V acid battery, and help the main battery to keep more energy to the drive.
The 0 Stage of the industrial switch, is an off mode, when the Solar System is off, and nothing is charged. The Voltage meter in the passenger cabin, shows the actual open circuit voltage of the system. This is important for us, because previous I mentioned that, we need to reach at least 16 Volts, from the Solar panels, to produce enough energy for the inverter to work.
This is only for the inverter, when we are parking and we can charge the main battery. Instead of the Voltage meter I could use a comparator, or operational amplifier switch to control the ON and Off stage, but it is need more wire, and it cost a lot of money.
The cheapest comparator switch solution would cost 35 thousand forints, which compare to the 500 HUF, what costs the voltage meter, pretty much. This is as easy solution, and we have the human touch to control the system.

For the DC-DC converter we need at least 18 Volts to operate. But when we reach around 17 Volts, on the Voltage meter, we can turn it on, and during the drive we can reach the lowest critical Voltage.

For the Wiring, I used high end audio car cable, to be flexible, and shielded from internal and external signals. Instead of using the commonly used industrial wires, I find this hi-fi cable capable, and more practical to use inside the cabin.

It is easy to hide, and twist. The AWG 8 standard shows that it has a 0.00206 ohm/m resistance and 8.36 core diameter. It is enough to transmit, and shield the power. Inside our home a 3.6 kW inverter use the same diameter, so it is mainly pass the circumstances.

The industrial switch is design for 500V DC switching, and can run 20Amps. This industrial switch prevents sparking, and have a long life, and durability.
The fuses and distributive manifold, holds up 2x 2,5Amps fuses, and operate with 230Volts.

The manifold is needed to divide the positive cable in to two ways. One way for the inverter, and one for the converter. It is work separately, so we need a separate circuit, but one solar panel supply.

These additional accessories, don’t have any influence for the electronics system, such as BUS system, inverters, converters, because the electric cars, have such smart systems, which can recognize, and overwrite the original function, such as charging etc.

This Universal Solar system can work, on every electric car, and made a simple, and cheap charging solution, and for extend the original range of the car.

4.2 Safety Reasons

To pass the regulations, and make a system for decades, I choose reliable, and quality components. I also take care about prices, so try to find the easiest solution. The main components are the inverter and the solar panel on this system, so I try to find a very good and reliable one from each.

The Solar Panel resist all the weather circumstances, and have a tempered glass coting, to resist scratches, and all the circumstances, in a normal usage, which can damage the panel.

The inverter is passed all the safety regulations, such as shock protection, has lighting protection, and the case pass all the IP 68 regulations, as shock and water resistant.
The case of the inverter is made by stainless coated cover, and made a perfect sealing for the electronical components.

The cables are also needed to satisfy the facts, as good connectivity, resist oxidation, has to be shielded, and has to be flexible. Instead of the commonly used wire, I prefer this one. The industrial switch is design for high DC current, to resist sparking, and work for around 60 million switching during lifetime. It is comfortable to use, and easy to build in to the back of the car.
The Fuse and Distributive Manifold also passes the IP68 regulations, and it is easy to use and fix it. It can distribute the power source, into 3 branches, but we need only 2, to supply the IQ6+ inverter, and B62SR converter. To fix the Solar Panel to the roof, I recommend, to use the official, original package holder on the roof. It is Easy to use, and we can fit any kind of Solar Panel to it with a suitable console.
For made a system theft-resistance, I recommend, to use special nuts, and bolts for fixing, and need special tools, to loosen the nuts, or bolt.

5. CALCULATIONS, CONCLUSION

5.1 Efficient Calculation

As we are in a final stage, we waited to see, how this system influenced the original range of the electric car. As we are working with the Nissan Lead 30kWh model, and use in urban circumstances, we will use the battery between 10% and 80 %, remain 2 kWh-26 kWh energy in the battery. As we say the lithium-ion battery charge is constant between this range, I will calculate also with constant powers, to simplify our model.
The following data is made by the PHOTOVOLTAIC GEOGRAPHICAL INFORMATION SYSTEM. In this webpage we can see the reachable solar power by day or month, calculated for the specific power of the system. For input I added my 277 Watts Solar system as 0,277kW and 0 degree for orientation, as the Solar Panel will on the top of the electric car vertical., and Budapest for the location, as we investigate with city conditions.

The Following data are presented in the database, and used to calculate:

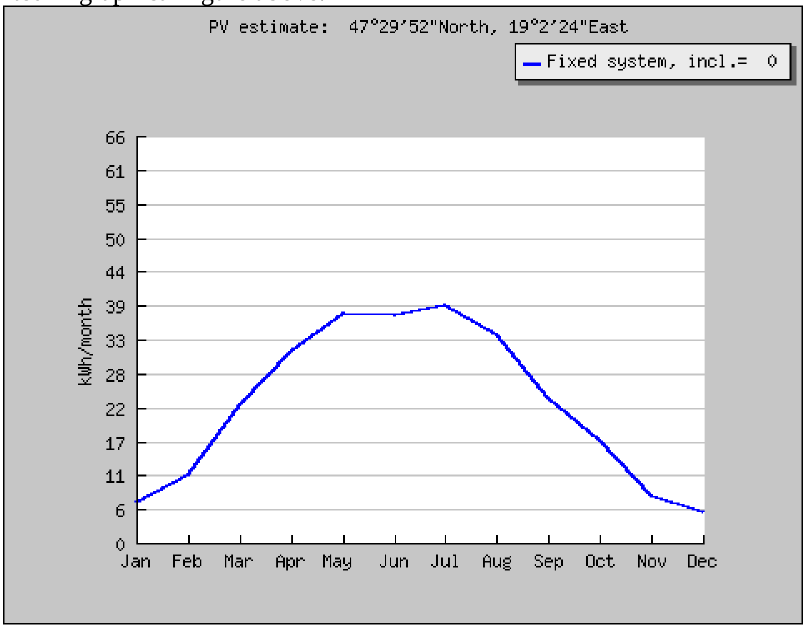
Fixed system: inclination=0 deg.
Latitude: 47°29'52" North,
Longitude: 19°2'24" East
Nominal power of the PV system: 0.277kWp
Inclination of modules: 0deg.
Orientation (azimuth) of modules: 0deg.
Fixed angle

Month	Ed	Em	Hd	Hm
January	0.21	6.65	0.96	29.7
February	0.40	11.2	1.72	48.1
March	0.73	22.7	3.18	98.7
April	1.05	31.4	4.67	140
May	1.21	37.5	5.53	172
June	1.24	37.3	5.80	174
July	1.25	38.8	5.91	183
August	1.10	34.1	5.15	160
September	0.79	23.6	3.59	108
October	0.54	16.7	2.41	74.6
November	0.26	7.75	1.17	35.1
December	0.16	4.98	0.73	22.7
Year	0.75	22.7	3.41	104

Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)
Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

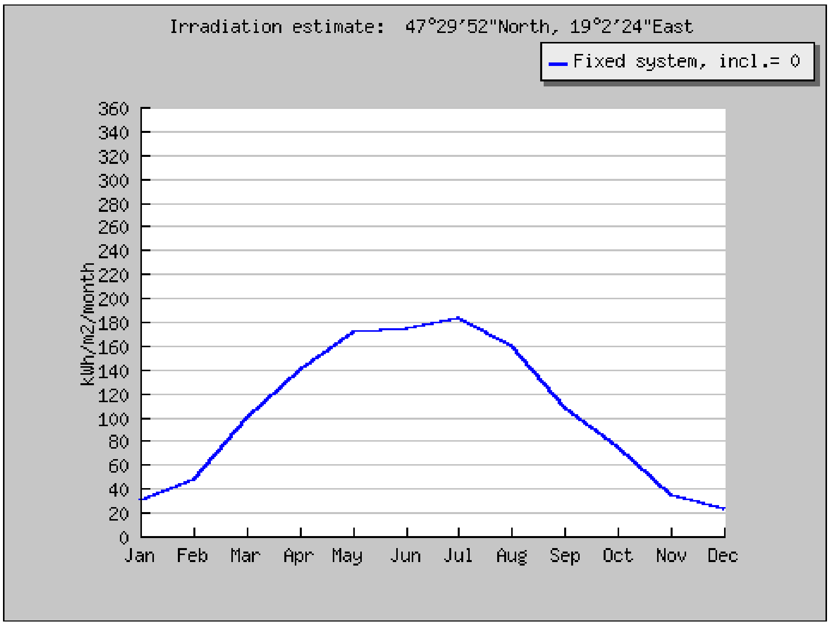
5.1 Given Database Based on the Input Data [39]

The data is represented in graphical figure above.



5.1.2 Monthly energy output from fixed-angle PV system [40]

We can see the production of our system, in a monthly division. As you may you see, there is a range between April and September, when you can charge your 30Kwh, battery more than 1 cycle of charge. This means we can run more than 200km with only the solar system.



5.1.2 Monthly in-plane irradiation for fixed angle [41]

The Monthly in-plane irradiation graph outfit is the same, as we talk about Kilowatt hours. The efficient is around 20% in the energy output, but it is correct, if we compare to the kWh/m2 production. If we summarize the data, we can easily create a model that shows, how many energy, percentage, and km add our solar system to the main battery.

If we put the fact that the Nissan leaf consume 13Kwh / 100 kilometers, we can figure out the following table, and see how many km can we add each month. From the data we can easily figure out the energy production, to monthly daily, and we can also see the cost earnings, due to the free energy.

To calculate the percent of charge monthly, we have to see first how much the production first. It is the opposite method, when we calculate the fuel consumption of a car. The Energy consumption of the Nissan Leaf we say 13 kWh / 100 km.

We see for example January, the monthly energy production was 6,65 kWh (Em), than we get nearly we add 51,14 kilometers per month, as (6,65 / 13) *100. The added Charge % / month, is also easy to calculate.

If we get the monthly km added calculated previous, we just divided the maximum range by km which can run with one charge. We discussed previous that the Nissan leaf can run around 200 km. 51,14 / 200 is 25,577 % so the calculation is correct. For the daily data, the same route needed to run, but first we need Ed data as we discuss with daily production.

For the cost is also easy, we get the monthly kW production, and we multiply with the actual cost of one kilowatt. I calculated with 40 Forints / Kilowatt, and I get the following results.

We might see that in daily, the Solar system work, not as much, but if we think about in a global year, the numbers are promising. We can see that in average year, we can daily add more than 5 km for our range.

For the weakest December month 1,2 km, the strongest July month we can add 9.6 km. If we think about, in daily, these are good numbers, compare that is free. If we see in monthly we have bigger numbers, so if we don't use every day our electric car, and we parked under the sun, we can get more higher ranges.

For cost the Solar system was cost around 220 000 forints, and we can see the earnings per year, due to the given system is nearly 11 000 forints, we can see that the system needs 20 years to return. So much, but the earned km is more important than the cost. In our country we have a few electric charge stations, and that few km, can save us to find a place to charge our electric car.

5.2 Modified Range Calculation

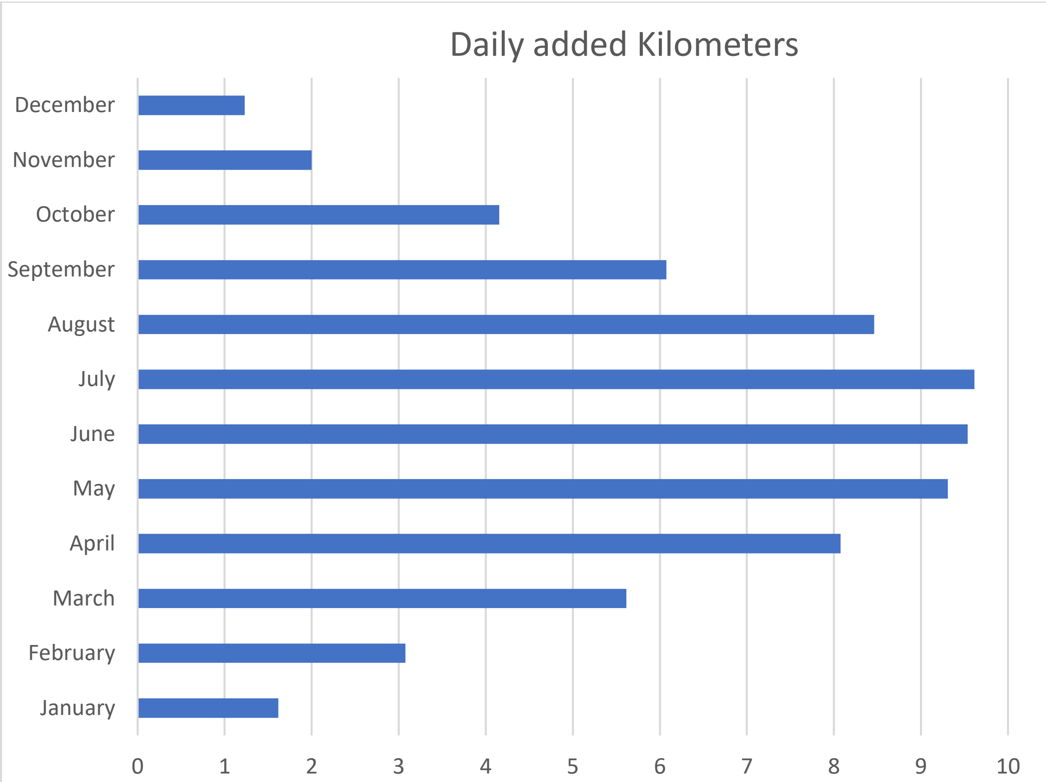
I made an excel table to summarize the output data, given by the PHOTOVOLTAIC GEOGRAPHICAL INFORMATION SYSTEM, and made some calculations to figure out how the system influence the consumption. I also made a cost calculation, for each month, and daily and monthly efficient calculation for the Solar system.

The following excel table are list below:

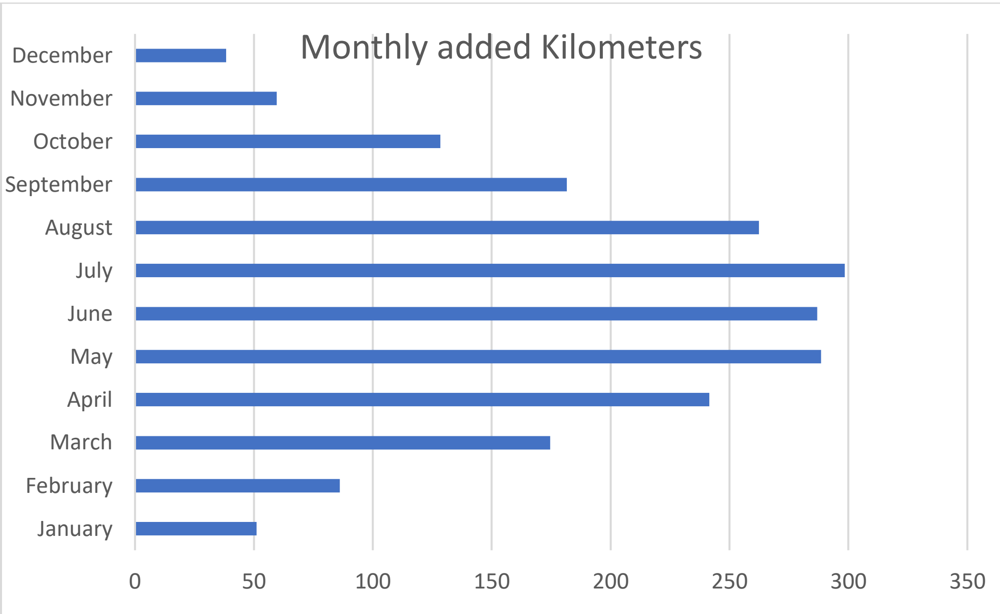
Month	Ed	Em	Hd		Km added Daily	Montly	Charge %/month	Charge %/daily	Earned cost/month
January	0,210	6,650	0,960		1,615384615	51,15384615	25,577%	0,808%	266
February	0,400	11,200	1,720		3,076923077	86,15384615	43,077%	1,538%	448
March	0,730	22,700	3,180		5,615384615	174,6153846	87,308%	2,808%	908
April	1,050	31,400	4,670		8,076923077	241,5384615	120,769%	4,038%	1256
Avarage Kw Jan-Apr	0,598	17,988	2,633		4,596153846	138,3653846	69,183%	2,298%	719,5
Month									
May	1,210	37,500	5,530		9,307692308	288,4615385	144,231%	4,654%	1500
June	1,240	37,300	5,800		9,538461538	286,9230769	143,462%	4,769%	1492
July	1,250	38,800	5,910		9,615384615	298,4615385	149,231%	4,808%	1552
August	1,100	34,100	5,150		8,461538462	262,3076923	131,154%	4,231%	1364
Avarage Kw May-Aug	1,200	36,925	5,598		9,230769231	284,0384615	142,019%	4,615%	1477
Month									
September	0,790	23,600	3,590		6,076923077	181,5384615	90,769%	3,038%	944
October	0,540	16,700	2,410		4,153846154	128,4615385	64,231%	2,077%	668
November	0,260	7,750	1,170		2	59,61538462	29,808%	1,000%	310
December	0,160	4,980	0,730		1,230769231	38,30769231	19,154%	0,615%	199,2
Avarage Kw Sept-Dec	0,438	13,258	1,975		3,365384615	101,9807692	50,990%	1,683%	530,3
Avarage SUM	0,745	22,723	3,402		5,731	174,795	87,397%	2,865%	908,933
							Earned cost(huf)/year		10907,2
Ed: Average daily electricity production from the given system (kWh)									
Em: Average monthly electricity production from the given system (kWh)									
Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)									

Summarize data from the PV solar database [42]

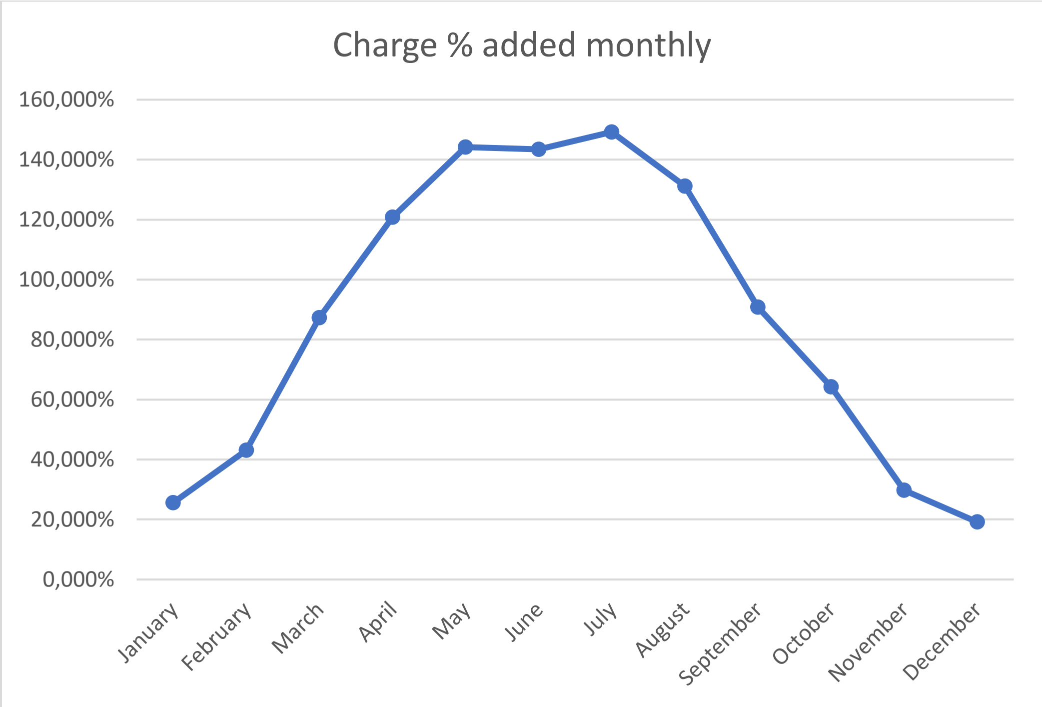
The graphical chart from the data is listed below.



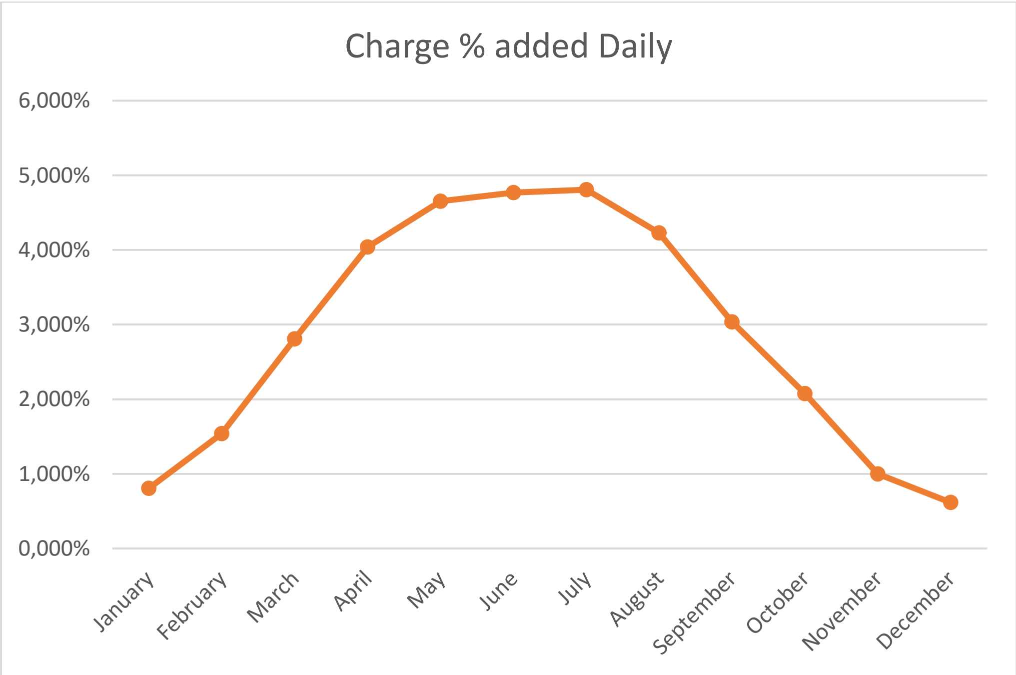
Daily added kilometers [43]



Monthly added Kilometers [44]

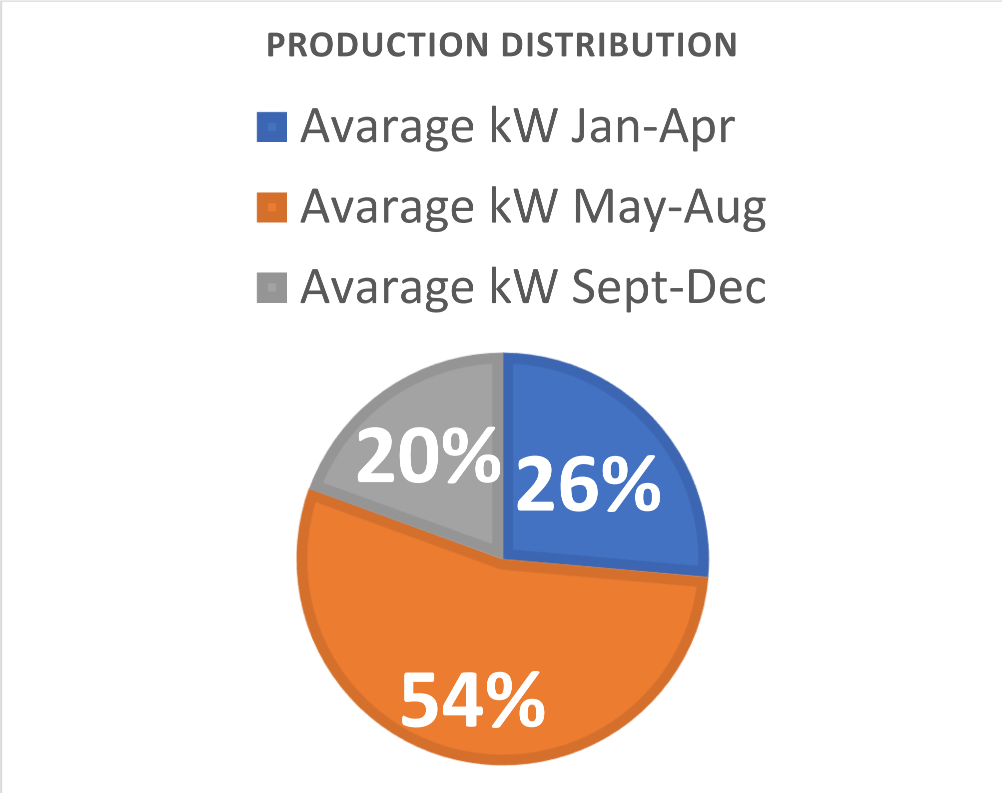


Monthly added charge in % for the main battery [45]



Daily added charge in % for the main battery [46]

If we see the distribution of the year into 4 months stages, the following pie we get. We can see when our system charge in minimum, medium, and maximum. We can also predict that in the summer, due to the higher number of sunny days, we reach more energy.



Year production distribution [47]

6. Conclusion/Summary

Final Conclusion: I proved that, we can build a system, that fits on every electric car, and can a practical accessory for it. We don't need to buy a car such as the Toyota Prius, where the system is integrated, and where we can only use on that. It is true that our system need more care, and it is needed to be plug the cable in every place where we stop, but it cost less, and I think it is product more energy for the batteries. As my calculations are pessimistic, I think it is produce more, as my solar system is bigger, more than two times, as the 180 W Panasonic solution. The Panasonic solution can add 5 kilometers in average only, if it works really on 180W production. My system is 375W, but I was very pessimistic, so I calculated with around 220W, so as in my ideal model. This system is suitable for the problem of self-discharge, that when we are in a holiday, example for 3 weeks, the electric car, won't lose any juice from the battery, and when we get back, we probably get in a fully charged electric car, thanks to the solar system. And it is also, the system can help to charge up our electric car, when we leave the car with a few days in parking anywhere.
For more energy production we need more area that we can cover whit solar panels, or we need more efficient panels to produce more energy for the system. I think in the future, this solution will have more focus, as more and more solar systems are installed on households. Our family also installed a 4 kW Solar system, to eliciting the electricity bills, and it is worked. It is also need 15 years to get back the investment, but if you compare a loan or investment, it has a high income. The same thing happens here, if you buy an accessory such as this solar system, you invest money that you can use for later.

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Vision Control of Automated Industrial Mechatronics System

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Abstract

Summed the project on the development of industrial automation platform VMS, which is a Mechatronics system that represents a miniature production line that consists of set electronic sensors and set of pneumatics and electric actuators, in addition to the programmable logical controller PLCs. The idea of the project is the development of this platform to replace a set of digital sensors that specify the type of produced piece material and height and whether the piece is perforated or not, the vision computer system is depends on the processing of the image obtained from a digital camera using Image Processing Toolbox within an environment MATLAB, then transferred as a result of processing image to the controller to give the orders to the actuators in order to sort the produced pieces within the warehouse according to a predetermined arrangement.

Keywords: Image processing, MATLAB, PLC, Color, Height, interface circuit.

1. Getting the image and image analyzing in MATLAB

1.1. Image structure in Compuer vision

Each image can be analyzed by **MATLAB** e.g. Noise filtering, edge detection, dilate (imdilate: adding extra pixels) and erode (imerode: removing unnecessary pixels). The image is a combination of three matrices which is RGB (red, green and blue), see fig.1 and fig.2. To define or read each basic color matric we can type in the command window the following:

r=image(:,:,1); g=image(:,:,2); b=image(:,:,3);

.

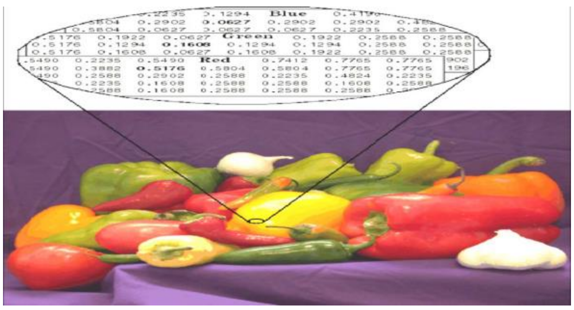

Fig.1. *shows the structure of the RGB image*

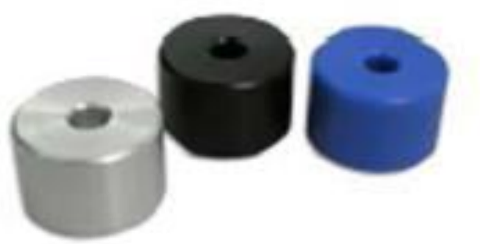

Fig.2 *the work pieces*

1.2. Getting the image to the MATLAB environment

1.1.1. Getting the image from saved location in the computer

We can load a saved picture from the computer and apply the processing algorithm on it, it's usually used for Simulink and Calibration purpose. In the image processing toolbox we use the instruction "imread(image_name.image_type)".

1.1.2. Getting Snapshot image from the Camera

First of all, the camera should be discovered by the MATLAB, this is can be done by selecting the camera name in the **webcamlist function.** Mainly, it's for real-time processing systems as shown in fig3. The instruction that we use is:

```
cam= webcam
img = snapshot(cam);
```

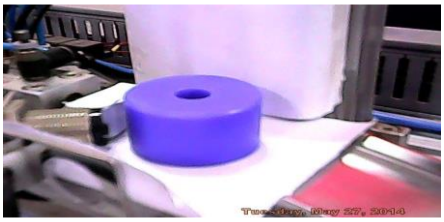

***Fig.3** shows the captured image in the work area*

2. Color detection for Black, Metal and Blue pieces

2.1. As the RGB image consists of three matrices, each matrix contains a value from 0 to 255 which zero means pure black color and 255 means pure white color. The color detecting procedure can be summarized as the following: by defining specific range of values for each matric considering the values of the color that we want to detect then and converting the original to a binary version (0 and 1 only) and multiply the set of desired value by it we obtain a new image with specific color and black color (0 value) for ignored color (out of our range).

2.2. Black Color detection

Due to the lighting condition and the reflected light on the workpiece can't consider that our values are only zeros. Therefore, we must calibrate until we get the best black color detection. I used the following code considering the lighting condition in the laboratory which effects on the values of matrix b1.

```
b1= r>0 & r<88 & g>0 & g<85 & b>0 & b<100;
area=bwareaopen(b1,8000);
bm=immultiply(area,b); gm=immultiply(area,g); rm=immultiply(area,r);
image=cat(3,rm,gm,bm);
figure,imshow(image);
figure,imshow(area);
[r,z]=find(area)
c=0
for i=1:r
for j=1:z
if i==1 && j==1
c=c+1;
end end
end
if c>0
msgbox('black')
data = bitor(data, 1)
end
```

Fig.4

Fig.5

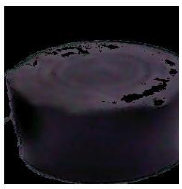

Fig.6

2.2 Metal Color detection

By considering the same condition and calibrating, we get a value near to 255 because it's a light color this case. The following code explains how to detect metal color.

```
r1=q(:,:,1); g1=q(:,:,2); b1=q(:,:,3);
m1= r1 >180 & r1 <255& g1 >90 & g1 <255 & b1 >180 & b1<254
area1=bwareaopen(m1,8000);
bm1=immultiply(area1,b1); gm1=immultiply(area1,g1); rm1=immultiply(area1,r1);
image1223=cat(3,rm1,gm1,bm1);
figure,imshow(image1223);
[r1,z1]=find(area1)
c1=0
for i1=1:r1
for j1=1:z1
if i1==1 && j1==1
c1=c+1;
end end end
if c1>0
msgbox('metal')
data = bitor(data, 3)
end
```

Fig.7

Fig.8

2.3 Blue color detection

in the blue color case we don't choose any value from red and green matrices(multiply them by zero), only from the blue matrices as it's a basic color and we choose all the values for this matric, so we can detect all degrees of blue color.

```
r2=q(:,:,1); g2=q(:,:,2); b2=q(:,:,3);
diff=imsubtract(b2,rgb2gray(q))
bw=im2bw(diff,0.18);
area2=bwareaopen(bw,300);
bm2=immultiply(area2,b2); gm2=g2.*0; rm2=r2.*0;
image=cat(3,rm2,gm2,bm2);
figure,imshow(image);
[r2,z2]=find(area2)
c2=0
for i2=1:r2
for j2=1:z2
if i2==1 && j2==1
c2=c2+1;
end  end  end
if c2>0
msgbox('blue')
data = bitor(data, 2)
end
```

Fig.9

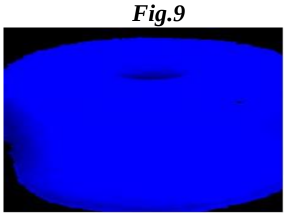

Fig.10

3. height detection

In our project we have three different heights for the workpieces as shown fig.4, the idea is to find the difference between maximum(top) and minimum(bottom) edge of the workpiece, to complete this procedure we use Edge detection filter which included in MATLAB image processing toolbox which gives us an image in binary version with white color for the edges (1-bit value). The following code used to detect the three heights and give a message box about the result.

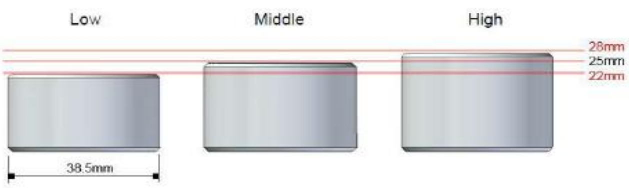

Fig.11 *the length of each piece*

```
q11=imcrop(im,[230 110 200 235 ]);
figure,imshow(q11);
I = rgb2gray(q11); % changes RGB input image into grayscale for edge detection
BW = edge(I,'canny',0.15);
area11=bwareaopen(BW,40);
[r11,c11] = find(area11);
subplot(1,2,1);
spy(area11);
x2 = max(c11);
x1 = min(c11);
X = x2 - x1
y2 = max(r11);
y1 = min(r11);
Y = y2 - y1
subplot(2,2,2);
imshow(area11);
if (Y>=212)
msgbox('high')
data = bitor(data,12);
if (Y>=195 && Y<=211)
msgbox('medium')
data = bitor(data, 8);
if(Y<=194)
msgbox('low')
data = bitor(data, 4);
```

Fig.12

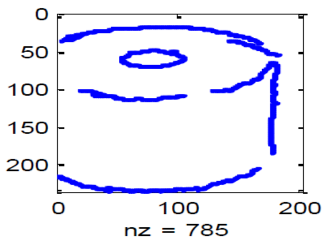

Fig.13

4. Surface (Hole) detection

we focus only on the part which contains the hole or not by cropping the original image. then by using ’for’ loop and edge detection. the loop scans the values of the cropped image if it is containing ones (more than 50) because less than 50 is considered as a noise so there are a hole and the vice versa.

```
counter=0;
found = 0; % a flag
 for j11=1:c11
  for i11=1:r11

    if(I(i11,j11)==1)
      counter=counter+1;
        found = 1;
    end

  end
end

if(counter >50)
    msgbox('hole detected')
    data = bitor(data, 16)
else
    msgbox('no hole')
    data = bitor(data, 0)
end
```

Fig.14

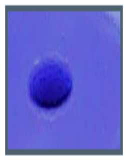

Fig.15

5. sending the data of the results to the PLC through serial port

to make the result understandable for the PLC which deals only with a digit (0,1) in other words (0-volt, 5-volt), we must export the result to serial port then to an interface circuit (RS232) which convert the resulting data to a digit. The data that we must send can be contained in one Byte and table.1 explain the distribution of the result on this Byte. As we got three cases of result for the color, three for the height and tow for hole detecting.

0	1	2	3	4	5	6	7
Color	Color	Height	Height	Hole	-	-	-

table.1 *The Byte of resulting data*

the function of the following code is to send the byte of data according to the result of color, height and hole detecting.

```
obj = serial('COM4','BaudRate',9600,'DataBits',8);
fopen(obj);
fwrite(obj,data);
fclose;
```

6. Conclusion/Summary

This research presented a method to replace the attached sensors to the work platform in the Mechatronics laboratory with a digital camera that detects color and the height (length of the piece) by the digital image processing program in MATLAB and the information was sent (result) to the PLC by the interface circuit MAX232 (serial port of the computer) between the computer and the PLC and the controller gives the orders for executing through a program programmed in Ladder Logic Language. The project achieved many goals:

- the connection between the computer and the PLC through an interface circuit for the serial port of the computer (RS232).
- A code was written in the MATLAB program digital image processing, which detected the color, height, and hole of the examined piece.
- When the color of the piece is discovered we have identified the type of the manufactured material, so the blue or black colors indicate that the material is plastic and silver color indicates that the piece is made of metal.
- The commands were sent from the computer to the PLC by the interface circuit and the PLC sent the commands to the actuators in the test section of the platform to move in a specific order and locate the piece in the depot.
- Also, in the interface circuit, the outputs that will be sent to the PLC with 8 Led are encoded 8bit and we take 5 bits to encrypt Cases of the colors, the heights and the hole of the specimen.

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