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Congratulation!

Edmond

Hajrizi, Rector of UBT and Chair of IC - BTI 2021

Development Trends of Mechatronics

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Abstract: Mechatronics is an interdisciplinary field integrating Mechanical Engineering, Electronics, and Computer Science. In this paper are presented the “face” of was changing dramatically over recent years. The complexity of devices and systems has increased dramatically, requiring a system-level approach to mechatronics design. This approach helps engineers to combine mechanical and control design, execute a test easily, and reuse algorithms within the final embedded delivery framework. This trend at system level is fuelled by growing investments in the fields of medical, life sciences and renewable energy as well as developments in industrial machinery. This approach greatly improves the design process by combining best practices and technology available to streamline design, prototyping, and implementation. By splitting the design process into parallel threads, the engineers may introduce a more efficient process of creation. Improving our way of life and the goods we use is not constrained by the common fields limits. In the nearest future, mechatronics will play a major role in enhancing the reliability, protection and affordability of products. In this paper are presented a development trends in Mechatronics and the future research will look into the negative effects of these technologies and necessary solutions to mitigate the threats.

Keywords: Mechatronic, Trends, Education, Cobots, Renewable sources.

1 Introduction

Mechatronics is an artificial word describing the integration of mechanical engineering with electronics, computer systems, and advanced controls to design, construct, and operate products and processes. Mechatronics is one of the newest branches of classic engineering with far-reaching applications. Generally, a mechatronic system can be seen as a mechanism, which is driven by actuators that are controlled via microelectronics and software using feedback from one or more sensors.

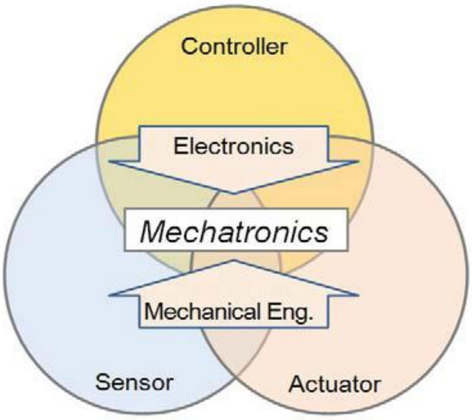

Fig.1 Basic components and disciplines of Mechatronics [1].

Mechatronics is therefore the title given to the sub-discipline of engineering which studies the integration of mechanical and electronic technologies to create 'intelligent' machines, systems and controllers. Mechatronics is an interdisciplinary field integrating Mechanical Engineering, Electronics, and Computer Science.

Failure of advanced technology projects has often been attributed to non-technical rather than technical problems. Research has postulated that the poor treatment of nontechnical issues within advanced engineering programmes has contributed to systems failure, as those charged with designing, developing and implementing the technologies have not been provided with the necessary set of skills and knowledge needed to manage these non-technical issues.

As a result, high profile professional bodies have called for a greater balance between technical and non-technical competences of technologists (for example review websites of Just IT Training & Recruitment (JP Morgan and Goldman Sachs International).

Mechatronics as an umbrella integrates areas of technology like measurement systems and sensors, actuation systems and drives, systems behavior, control, and microprocessor systems.

Currently we have the following Mechatronic systems requires the following theoretical basic knowledge:

- Conventional: Classical Mechanics, Electronics, Control Engineering.
- Micromechatronic Systems – MEMS: Classical Mechanics, Electronics, Control Engineering
- Nanomechatronic Systems – NEMS: Quantum Theory, Advanced Control Engineering
- Femtomechatronic Systems – FEMS: Quantum Theory, Advanced Control Engineering
- Atomechatronic Systems - ATEMS
- Conventional, and Micromechatronics Systems are realized since 2000
- Nanomechatronic systems are in realization.
- FEMS will be realized in 2-3 years and
- Atomechatronic Systems – ATEMS are currently a dream.

The definitions "What is Mechatronics" are quite different like: "Integrated optimal design of a mechanical system and its embedded control system. Not every controlled mechanical system is a mechatronic system. In many cases the control is just an add-on in a sequential design procedure. The most important term is Embedded". Mechatronic design is a teamwork of specialists from Mech.Eng., Electrical. Eng., Control. Eng.) supervised by a Mechatronic Manager [1].

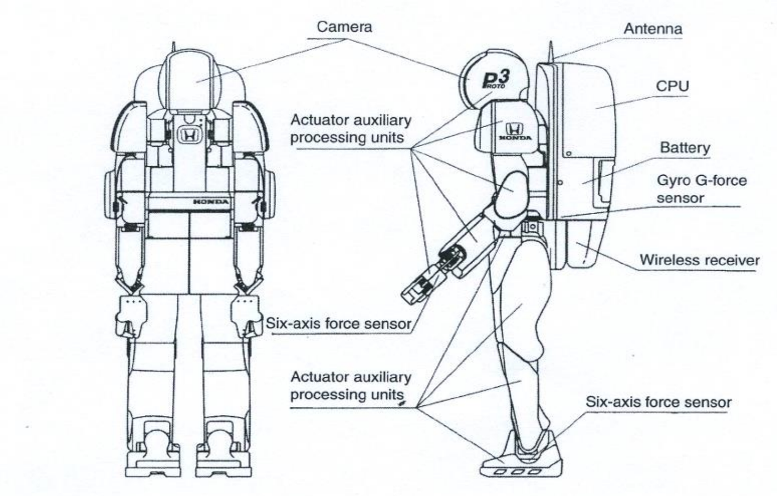

FIGURE 1.2(b)
Components of a humanoid robot. (American Honda Motor Co. With permission).

Fig.2. A humanoid robot as a frequently used example of a Mechatronic System [1]

Classical examples for mechatronic systems are mass-produced products like washing machines, dish washers, microwave ovens, cameras, watches, hi-fi and video recorder systems, central heating controls, sewing machines, smart homes or for (self-driving) cars active suspension, antiskid brakes, engine control, speedometer display, transmission, assistance systems. In Production Automation Production 4.(5,6).0, networked robots, collaborative robots, cooperative robots.

2. Education in Mechatronics

A mechatronics technician use engineering and mathematical principals to implement and maintain electronic systems lie those used for computers. It is a new career that is considered multi-craft that focuses on the skills needed to work on robotic and intelligent equipment. Currently a mechatronics technician have to have knowledge able to work on anything from banking machines to multi-million dollar, highly complex mechanical equipment. Often mechatronics technicians assist in the design/development and engineering staff to develop, repair and maintain electronic/robotic systems and individual components. The may be involved with the development of a product from the conception through testing and production. Therefore he or she must to be educated in:

- Applied mechanics
- Advanced control
- Pneumatics and hydraulics
- Computer software/hardware
- Materials science
- Analog and digital communications
- Advanced programming methods.

For example in Austria we have currently a lot of new education programs [1]

3. Trends in Mechatronics

The “face” of was changing dramatically over recent years. The complexity of devices and systems has increased dramatically, requiring a system-level approach to mechatronics design. This approach helps engineers to combine

mechanical and control design, execute a test easily, and reuse algorithms within the final embedded delivery framework.
This trend at system level is fuelled by growing investments in the fields of medical, life sciences and renewable energy as well as developments in industrial machinery. This approach greatly improves the design process by combining best practices and technology available to streamline design, prototyping, and implementation. By splitting the design process into parallel threads, the engineers may introduce a more efficient process of creation. In the past a team has had to wait for a practical prototype to create a control algorithm for a mechanical device. Now engineers can use a virtual prototype based on concept models and simulation data to get started faster.
Ghost of Computing entails a decline in electronics capacity/size (miniaturization). When the size of the technology required for a computer is getting closer and closer to zero, the problem is no longer how much smaller and more powerful the technology can be produced, but what the technology can be used in now. Society is reaching a peak and turning point where there seem to be no end to limitations and mechatronic minds are able to realize every existence. Mechatronics supports broad areas of interdisciplinary expertise. Improving our way of life and the goods we use is not constrained by the common fields limits. With the ever-changing demands and requirements of a dynamic and complex world, to keep in tandem, technologies and inventions have to progress at a very fast pace. In the nearest future, mechatronics will play a major role in enhancing the reliability, protection and affordability of products. Future research will look into the negative effects of these technologies and necessary solutions to mitigate the threats [2].

4. Mechatronics Management

It was clear that mechatronic managers must possess the core skills of mechanical engineers and electrical engineers as well as management and business. Their knowledge enables them to supervise or solve a wide range of mechanical, electrical and software problems, allowing them to participate in and lead multidisciplinary design teams.
Furthermore, they have to have the usual competencies from Engineering Management
Technical Competence: the individual has sufficient subject knowledge and can plan and organise so as to achieve maximum results.
Administrative Competence: the individual has a range of business knowledge, can follow rules, procedures and guidelines set out by the organisation and can perform to the expected standards set out by the organisation.
Ethical Competence: The individual has moral standards which guide them in their decision making activities in the work environment.
Productive Competence: The individual is efficient and capable of producing desirable results. Productive competence particularly focuses upon the capability of the professional to continuously develop their knowledge and skills.
Personal competence: The individual can manage time, possesses necessary ‘people skills’, time management, communications and conflict management skills to operate effectively in the working environment. [1]

5. Examples

5.1. Robotics

Automation and robotics excel in the manufacture of standardised products using standard manufacturing processes in high volumes to an excellent quality standard. When creativity or customisation is expected, the human being is key. The solution is the collaboration of robots and the humans. Traditional robots cannot work side by side with humans but Cobots are designed to work in synchronisation with human employees and were first developed in 2012 in Denmark.
A Cobot is not a replacement robot; it assists workers rather than replaces them. These robots are safe around humans by using force limiting sensors and rounder geometries than traditional robots. They are lightweight and thus are easily moved from task to task. In addition they are easy to implement and use without a specialised automation Engineer or Technician. In fact, an Operator with Cobot programming skills can deploy it. Another

advantage mentioned previously is that Cobots are so affordable that it is a worthwhile investment for any company, regardless of the size of the company.
Cobots are extremely versatile and can be used for a wide variety of applications, examples of which include: Packaging and Palletizing, Machine Tending, Industrial Assembly, Pick and Place, Quality Inspection, Injection Molding, CNC Tending, Assembly, Polishing, Screw driving, Gluing, Dispensing and Welding. They can be easily changed over from one operation to another is a very short time. At the moment they are being used in the larger manufacturing companies but there is an opportunity to introduce this technology into small to medium size companies [3]
As detailed by the ISO10218 standard, robots can have four types of safety features. They are:

- Safety Monitored Stop
- Hand Guiding
- Speed and Separation Monitoring
- Power and Force Limiting

The safety monitored stop is implemented in environments where the robots operate mostly alone, with occasional human interference. The feature will cause the robot to pause (though not shutdown) when the safety zone is violated (i.e. a human enters its workspace). The speed and separation monitoring feature are an extension of safety monitored stop. Instead of adopting a single behaviour throughout the robot's entire workspace, the latter is gradated into several safety zones.
The research is called "The Industrial Collaborative Robots Competitive Assessment" concluded that Universal Robots (UR) were leading, particularly when focusing on the implementation volumes. The companies ranked in the assessment were: ABB, Aubo Robotics, Automata, Doosan Robotics, FANUC, Franka Emika. Kuka AG, Precise Automation, Productive Robotics, Techman Robot, Universal Robots. Yaskawa Motoman

Fig.3: Cobots [3]

5.2 Renewable Energies

Mechatronic and renewable energy systems are all over our world, with electrical energy as their basis. Renewable energy systems such as: Photovoltaic (PV) systems, concentrated solar power (CSP) systems,

Wind turbines, geothermal power plants, Wave converters, and Bio gas power plants, "produce" electrical energy [4]. Mechatronic energy systems consume and/or (partially) store electrical energy. The importance of Mechatronic Engineering will further increase due to consumer demands for “smart” tools, devices and systems. Hence, mechatronics is described as mechanical engineering for the 21st century [5].

The importance is a reliable and efficient operation of these systems and their interconnection with the future power grid to ensure global welfare and sustainability.

5.3 Production Automation

Kopacek in 2019 stated that industry 4.0 combines production methods with state-of-the-art information and communication technology. The driving force behind this development is the rapidly increasing digitization of the economy and society, and the result, manufacturing and the work environment are irreversibly changing exponentially. In the tradition of the steam engine, the production line, electronics and information technology, smart factories are now determining the fourth industrial revolution. The technological foundation is provided by intelligent, digitally networked systems that will make largely self-managing production processes possible [6]

The focus of Europe is now on the implementation of strategic concepts. With a strong technical foundation, the challenge in Europe is to balance the opportunities of digitalisation in industrial value creation with the needs of a human-centric world of employment. Europe sees Industry 4.0 and 5.0 as a socio-technological challenge. Reclaiming industrial competitiveness is critical in manufacturing as well as the preservation of sustainable careers. Breque et al state that “there a consensus on the need to better integrate social and environmental European priorities into technological innovation and to shift the focus from individual technologies to a systemic approach.” [7]

A framework of the emerging Industry 5.0 can be seen in figure 1 as proposed by Doyle-Kent in 2021 [8]. The importance of education leading this field cannot be underestimated, and an interdisciplinary approach combining the technological, social ethical, industrial, environmental and management aspects is required going forward to enable graduates not just to survive but to flourish in their future careers.

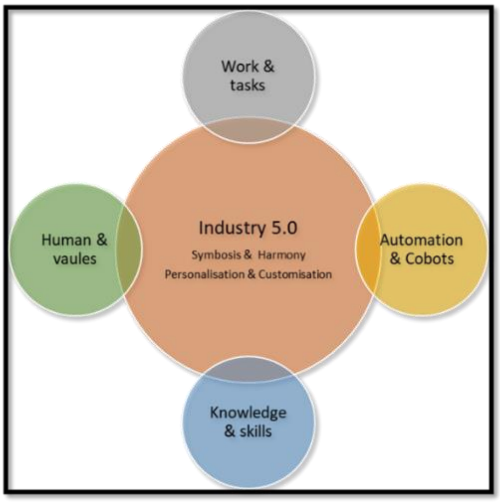

Fig. 4. Conceptual framework illustrating Industry 5.0 [8]

Additionally an Industry 5.0 definition has been put forward by Doyle-Kent so that researchers can easily conceptualisation this paradigm shift that is fast approaching. “Industry 5.0 is the human-centered industrial revolution which consolidates the agile, data driven digital tools of Industry 4.0 and synchronises them with highly trained humans working with collaborative technology resulting in innovative, personalised, customised, high value, environmentally optimized, high quality products with a lot size one.” [8].

6. Summary and Outlook

In this paper are described a newest trend in Mechatronic, such as: Education, Management, Robotics, Cobot, Renewable energies, Industry 5.0 etc., in field and framework of Mechatronic The complexity of devices and systems has increased dramatically, requiring a system-level approach to mechatronics design. This approach helps engineers to combine mechanical and control design, execute a test easily, and reuse algorithms within the final embedded delivery framework. Newest trends in Mechatronic energy systems consume and partially store electrical energy. The importance of Mechatronic Engineering will further increase due to consumer demands for “smart” tools, devices and systems. In this paper Mechatronics is described as mechanical engineering for the 21st century, where the importance is a reliable and efficient operation of these systems and their interconnection with the future power grid to ensure global welfare and sustainability. Focus in future regarding development trends in Mechatronics is to look into the negative effects of these technologies and necessary solutions to mitigate the threats.

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References

[1] Kopacek P., “From Engineering to Mechatronics Management,,” in *Proceedings of the IFAC Workshop on “Supplementary Ways to Improving International Stability - SWIIS 2013”, University for Business and Technology,,* Prishtina, Kosovo., 2013.

[2] Chiebuka T. Nnodim1, “Future trends in mechatronics,” *IAES International Journal of Robotics and Automation (IJRA),* vol. 10, no. ISSN: 2722-2586, DOI: 10.11591/ijra.v10i1.pp24-31, pp. pp.24-31, 2021.

[3] U. Robots, “COBOT APPLICATIONS,” 10 11 2020. [Online]. Available: https://www.universal-robots.com/blog/cobot-applications/. [Accessed 14 10 2021].

[4] C. T. U. -. M. e. a. r. e. systems, “Capitol Blog,” 27 7 2020. [Online]. Available: https://www.captechu.edu/blog/mechatronics-engineering-and-renewable-energy-systems. [Accessed 13 10 2021].

[5] V. R. Mamilla, “A Mechatronic System for Power Control,” *International Journal of Applied Engineering Research,* vol. Volume 5 , no. Number 5 (2010), p. 779–784 , 2010.

[6] P. Kopacek, “Robo-Ethics a Survey of Developments in the Field and their Implications for Social Effects,” *IFAC-PapersOnLine, 52(25), . ,* no. t DOI: https://doi.org/10.1016/j.ifacol.2019.12.460, pp. 131-135, 2019.

[7] M. Breque, “Industry 5.0. Towards a sustainable, human-centric and resilient European industry,” Publications Office of the European Union, Luxembourg. Available [Online] at DOI: https://op.europa.eu/en/publication-detail, 2021.

[8] M. Doyle-Kent, “Collaborative Robotics in Industry 5.0 (Doctoral dissertation, Wien).,” TU Vienna- DOI: 10.34726/hss.2021.70144, Vienna, 2021.

Barriers in Implementation of Lean Manufacturing Techniques in Kosovo's Industry

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Abstract. *By application Lean Manufacturing Techniques, enterprises can eliminate wastes in the manufacturing system as well improve the effectiveness of the organization. According to the literature review and author investigation, the application of Lean Manufacturing Techniques in Kosovo's enterprises is at a low level. Therefore, this investigation attempted to explore the main barriers in the implementation of Lean Manufacturing Techniques in Kosovo's Industry. Analyses have been done based on questionnaires and interviews with experts and employees in enterprises that have implemented as well as enterprises that are in process of implementation of the lean model. Several problems have been highlighted and are categorized into six groups; knowledge, management, resource, conflicts, employee and financial.*

Keywords: Kosovo Manufacturing Industry, Lean Manufacturing Techniques, Small and Medium Enterprises, Barriers implementation

1 Introduction

There are a lot of Lean Manufacturing Techniques (LMTs) which are used in today's enterprises all around the world. Each of them has its benefits and advantages.

The essential goal of Lean Manufacturing Techniques is to improve flexibility, quality and response time to the customer by improvements in productivity, quality, delivery and minimization the cost of the product. Enterprises by using LMTs intend for the identification and reduction of waste as much as possible, they try to improve customer satisfaction, a condition that surrounding the environment of enterprise by eliminating material waste, energy waste, water waste, and so on. Most of these things are related to the document of the European Commission about Industry 5.0 (Towards a sustainable, human-centric and resilient European industry) Breque et al. [1]. Therefore, the adoption of lean manufacturing in Kosovo's enterprises is crucial in their way towards Industry 4.0 and Industry 5.0. This highlights the main research question: What are the biggest barriers that obstruct the implementation of Lean Manufacturing Techniques in Kosovo's Industry?

Manufacturing and improvements in manufacturing processes are essential in the process of turning existing factory plant structures into smart factories able to compete in the global market - transforming smart enterprises [2], [3].

According to the article [4] (own study), in the application of Lean Manufacturing Techniques in Kosovo's enterprises, results show that the application of Lean Manufacturing Techniques in Kosovo's enterprises is at a low level. About 66% of enterprises in Kosovo's Industry are not using LMTs. Therefore, the main purpose of the paper is to investigate the barriers in the implementation of Lean Manufacturing Techniques in the Kosovo's Manufacturing Industry; a study of its practice across the industry was investigated. The questionnaire is used to collect the data from manufacturers on barriers during the implementation of Lean Manufacturing Techniques within SMEs in the Kosovo's Manufacturing Industry. From questionnaires and interviews with experts from the industry, the aim was to understand the common challenges and barriers that the enterprises face when implementing the Lean Manufacturing Techniques in their facilities.

2 Literature review

Wastes in product development are unavoidable, but they have to be minimized as much as possible to have profitable and sustainable product development performance. Most of the wastes are dependent on time and process and may be expressed in terms of costs, rework, lead time, defect rate, etc. To be successful in a competitive business environment, managers need to know how to organize as well as how to develop products and manufacturing. Lean product development is an approach to organize product development, according to a set of techniques-principles [5]]. Studies on the barriers in the implementation of lean techniques can be found by many authors in different countries, but there is a gap for the Kosovo's Manufacturing Industry. Extensively have been discussed the concept of Lean Manufacturing Techniques and its barriers in the last decade by different authors. According to Bayhan et al. [6] the most enablers for lean manufacturing are financial, managerial, technical, workforce, and culture. Kumar and Kumar [7], have condensed seven major attributed barriers in the Implementation of Lean Manufacturing Techniques as following: management, resource, knowledge, conflicts, employee, financial and past experience. Whereas, Salontis and Tsinopoulos [8], the barriers have grouped into four levels: financial barriers, top management related barriers, workforce-related barriers and other barriers. Based on the response of the employees, according to Ingaldi et al.[9], several problems have been highlighted during the implementation of Lean Manufacturing Techniques; with the most important being insufficient communication in the enterprise, excessive pressure of the owners and lack of support of top managers. The most important causes of insufficient effects of the implementation of Lean Manufacturing are the lack of commitment of employees, lack of self-discipline and tendencies for returning to old habits.

3 Research Methodology

The goal of this investigation is to determine the barriers to Lean Manufacturing implementation within the Small and Medium Enterprises of the Kosovo's Manufacturing Industry. This study has been done in the SMEs (manufacturing companies) in the industry of Kosovo. This research has included the companies that have effectively adopted the Lean Manufacturing system, as well as the companies that are in the process of implementing Lean Manufacturing.

The methodology investigation has been done by the questionnaire and interviews. Several preparatory visits have been done in Kosovo's enterprises to be informed about the research problem and preparing the design of the questionnaire and interview questions.

From 186 questionnaires delivered, 95 have been received completely answered.
Afterwards, an analysis of collected data has been carried out to identify the barriers in Kosovo's enterprises.
To improve the effectiveness of the questionnaire, the questionnaire was pretested in several enterprises and have been taken proposals experienced by experts in the industry. Figure 1 presents the flow diagram of the research methodology.

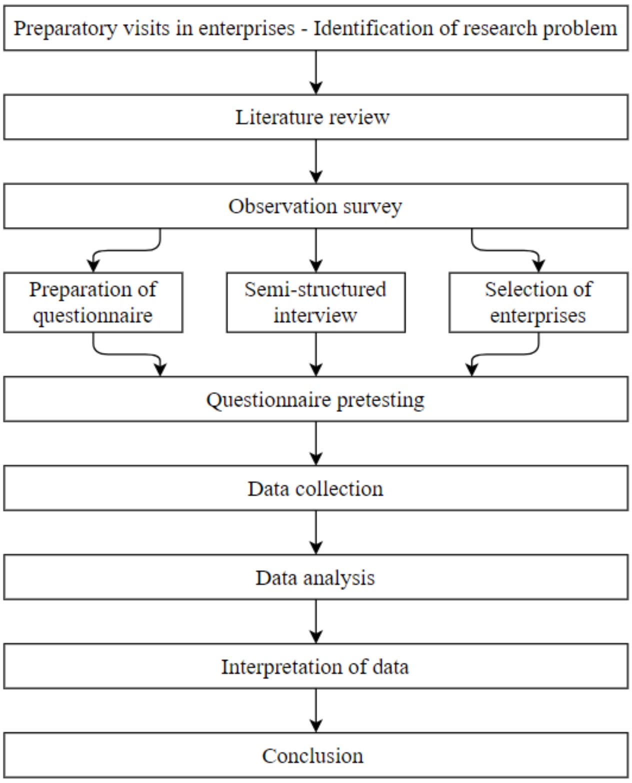

Fig. 1. Flow diagram of our working research methodology

4 Results and analyses

4.1 Descriptive and inferential analysis of surveyed companies

For the enterprises which are using Lean Manufacturing Techniques as well as the enterprises that are in the process of implementing Lean Manufacturing, the question was, what were the biggest problems when trying to use LMTs? According to the literature review, one of the major barriers for SMEs is the absence of top management support and knowledge [10], [11]. Management and employees resist change and develop practices that also obstruct lean implementation in SMEs. According to Salaheldin [10], some constraints include shortages in management, lack of financial resources for SMEs in their path of becoming lean. This financial absence influences the training and prevents SMEs from having the proper training for their employees. Lack of skilled resources for implementing Lean Manufacturing Techniques is another obstacle for small enterprises [[10]]. Other barriers found from the literature review are lack of planning, lack of management commitment, lack of methodology during the phase of implementation, human aspects, et cetera. According to the survey based on the responses of respondents from the Kosovo's Manufacturing Industry, figure 2 shows the main barriers that have been found in the Kosovo's enterprises implementation of Lean Manufacturing Techniques.

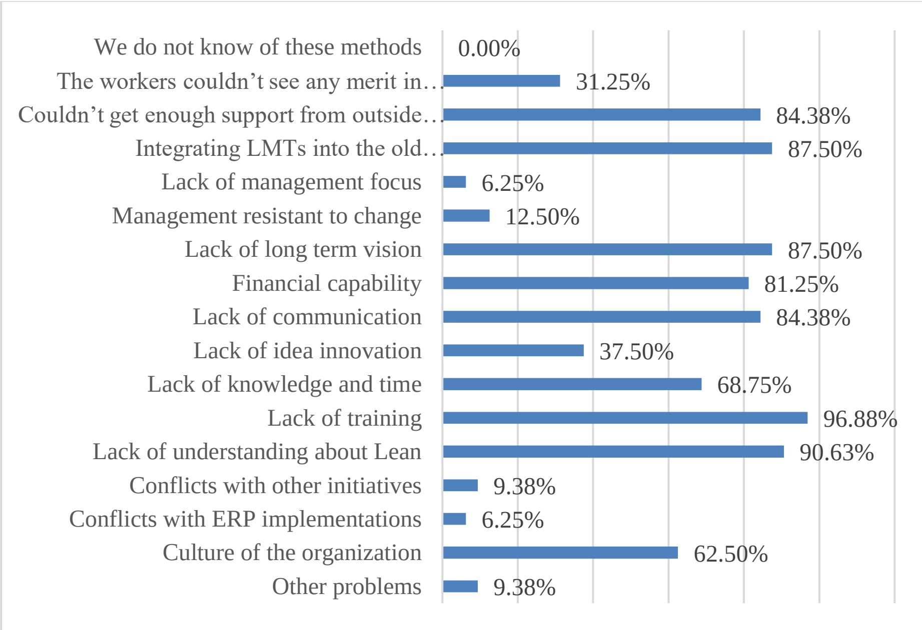

Fig. 2. Main barriers for Kosovo's enterprises trying to adapt LMTs

As can be seen from the graph in figure 2, based on the response of respondents, the main barriers when the enterprises are trying to adopt Lean Manufacturing Techniques include: lack of training, lack of long term vision, lack of understanding about lean, integrating Lean Manufacturing Techniques into the old conventional production system, lack of communication, could not get enough support from outside to receive the necessary resources to adopt Lean Manufacturing Techniques, lack of knowledge and time, the culture of the organization.

For the question about how important it is for the enterprise to become lean, figure 3 shows the percentage of importance.

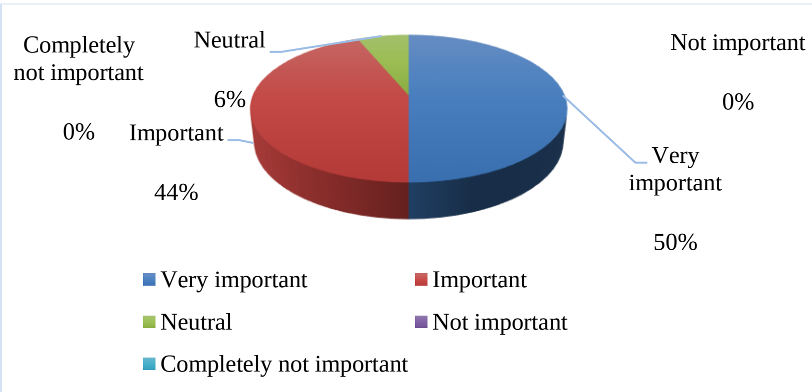

Fig. 3. The percentage of importance for enterprises to become lean, based on the response of respondents

Most of the respondents have been answered that is very important for enterprises to become Lean, and none of them has been answered as not important.
It should be mentioned that for this question, the analysed data come from the enterprises that are using Lean Manufacturing Techniques and the enterprises that are in the process of implementing Lean Manufacturing.

4 Conclusion

In this article are presented the results of a questionnaire survey and interviews, which have been conducted in Kosovo's enterprises related to the problems encountered during implementation of the Lean Manufacturing Techniques. According to the results, have been indicated several barriers during the implementation of Lean Manufacturing Techniques in Kosovo's Industry, are as follows; lack of training, lack of understanding about lean, lack of long term vision, integrating Lean Manufacturing Techniques into the old conventional production system, lack of communication, couldn't get enough support from outside to receive the necessary resources to adopt Lean Manufacturing Techniques, lack of knowledge and time, the culture of the organization. According to the literature review and results from this investigation, the barriers can be categorized into six groups: knowledge, management, resource, conflicts, employee and financial.
The results of this investigation could be considered as helpful for practitioners to be aware of barriers during the implementation of the lean model in Kosovo's Industry.

5 References

[1] M. Breque, L. Nul, and A. Petridis, "Industry 5.0 (Towards a sustainable, human-centric and resilient European industry)," Brussels, 2021. doi: 10.2777/308407.

[2] F. Azemi, R. Lujić, G. Simunović, and D. Tokody, "Selection the Basic Lean Manufacturing Techniques in Developing the Model for Industry 4.0 in KosovoManufacturing Industry," in *The 14th International Conference on Interdisciplinarity in Engineering—INTER-ENG 2020)*, 2020, pp. 1–8, doi: https://doi.org/10.3390/proceedings2020063062.

[3] I. Veza, M. Mladenio, and N. Gjeldum, "Selection of the basic lean tools for the development of Croatian model of innovative smart enterprise," *Teh. Vjesn.*, vol. 23, no. 5, 2016.

[4] F. Azemi, G. Simunović, R. Lujić, and H. Altaleb, "Application of Lean Techniques within SMEs in Kosovo Manufacturing Industry and benefits of implementation," in *International Conference on Mechatronics, system engineering and Robotics & Informations System and Engineering*, 2020, pp. 12–16, [Online]. Available: https://knowledgecenter.ubt-uni.net/cgi/viewcontent.cgi?article=3151&context=conference.

[5] J. K. Liker and J. M. Morgan, "The Toyota Way in Services: The Case of Lean Product Development.," *Acad. Manag. Perspect.*, vol. 20, no. 2, pp. 5–20, 2006, doi: 10.5465/AMP.2006.20591002.

[6] G. Bayhan, S. Demirkesen, and E. Jayamanne, "Enablers and Barriers of Lean Implementation in Construction Projects," in *IOP Conf. Series: Materials Science and Engineering*, 2019, pp. 1–8, doi: doi:10.1088/1757-899X/471/2/022002.

[7] R. Kumar and V. Kumar, "Barriers in Implementation of Lean Manufacturing System in Indian industry: A survey," *Int. J. Latest Trends Eng. Technol.*, vol. 4, no. 2, pp. 243–251, 2014.

[8] K. Salonitis and C. Tsinopoulos, "Drivers and Barriers of Lean Implementation in the Greek Manufacturing Sector," in *49th CIRP Conference on Manufacturing Systems (CIRP-CMS 2016)*, 2016, pp. 189–194.

[9] M. Ingaldi, S. Dziuba, and A. Cierniak-Emerych, "Analysis of problems during implementation of Lean Manufacturing elements," in *MATEC Web of Conferences 183*, 2018, pp. 1–6, doi: https://doi.org/10.1051/matecconf/201818301004.

[10] S. Ismail Salaheldin, “JIT implementation in Egyptian manufacturing firms: some empirical evidence,” *Int. J. Oper. Prod. Manag.*, vol. 25, no. 4, pp. 354–370, 2005, doi: 10.1108/01443570510585543.

[11] P. Achanga, E. Shehab, R. Roy, and G. Nelder, “Critical success factors for lean implementation within SMEs,” *J. Manuf. Technol. Manag.*, vol. 17, no. 4, pp. 460–471, 2006, doi: 10.1108/17410380610662889.

Cost oriented image processing for mobile robots

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Abstract.
Mechatronic is used in a lot of activities, and our study intends to add supplementary components making the system more intelligent. A mobile robot which follows the path while avoiding obstacles and using the implementation of image processing on real worldThe economic aspect has become a major part of the investment in technology and needs to be taken into account. Project was of low cost, and there will be no impacts for not implementing this project in the future, considering little equipment added. Hoping the results of this work will be taken into consideration for further generations of mobile robots that can be improved and smarter, as nowadays, robots are used as waiters, nurses, taxi, delivery robots. Therefore, focus will be on measuring the object from the imagesprocessin in real time taken by the camera in order to create a code which will plan a new pathway and solve any situation with parallax camera mounted in front of mobile robot as car kit.

Keywords: Robot, intelligence, Image processing, Obstacles, measure, camera, objects, cost oriented

1 Introduction

In regard to human eyes intell infers distance from two images taken from different views, which is connected to image processing, especially in automation systems, this couldn’t be possible without it. According on our experience also had instances of security camera installation and perhaps detecting some of its missing effects. There is a requirement to improve and update this field of activity. (Ahmed, M. F. 2006)

As a cost oriented idea there will be other way to reuse or use the existing applied techniques by just adding more details to the analysis. This is understood and justified in economic aspects.
During the working process will face four situations, where each of them should be solved. Also need to know some parameters before started working with smart car tolerance to overpass object, focal length of camera and its resolution, etc. Veven some parameters and guide to mount it is from producer company. (STEM 2019)

During this work when it is known thare is no calibration field and everything will be done in real time, it is known in advance that there should be a faster data transmission speed, finding the distance or point where to make decision to achieve more accuracy results.
As this project will only be based on one object as obstacle and must be regular object on shape, and its analysis must be in 2 dimensional a care should be taken that the environment does not interfere with other obstacles. When working with cameras that support HD technique and the resolution is higher, some little obstacles should be canceled or ignored through the filters or until creating code to do any condition like to measure just when it is closed shape.
The scope is mainly about mechatronic system that will include electronics, mechanical and programming components, that is, the mechatronics field includes equipment that will be completed with accessories and additional components. No specific circuit will be constructed, but their connection and its assignment of new tasks will be taken into consideration. Programming implemented to create a code that will be used on the existing programming language such as python by not having a need for creating a new code. The proposed measurement procedure is a three-phase process: object detection, segmentation, and distance calculations. (Tsung-Shiang Hsu and Ta-Chung Wang 2015)
The main goal is to make the robot car smarter, acting more independently, setting of certain rules (decisions) through programming obtained from image processing. Further objectives but with less importance to this project is to achieve and to create something which can be applied in practice as an alternative, by other words to adapt to it using just some parameters.
At the same time it is not to produce further equipment knowing the recommendations coming from WEEE or to create any trouble on the resource efficiency, but using of existing tasks and to expand their tasks.

2 Literature review

While researching the literature using various books, thesis, scientific publications, and other sources, found many conclusions and works of our nature, this will assist us to continue the specificity of our project.
Algorithm is implemented to enhance an image in different enhancement degree using the raspberry pi. The algorithm developed for the raspberry pi executes successfully and gives a very colorful image. Input images are multicolored while output may be either an image or a video frame or a set of characteristics or parameters related to the image and has taken or moved some effects, like gray image, Gaussian filtered image, contrast stretched enhanced Image, noise removal image etc. (K.S.Shilpashree, Lokesha.H, Hadimani Shivkumar, 2015).
Compared to our project, maybe the output part of the image presented by Gaussian filtering can work with some changes, as far as concerning other parts here, maybe because the purpose of our work is to present the output as a closed contour of the creation of effects to eliminate any interference and implications. But flow diagram part has same principle, but mine will have more embedded system meaning with many parts like mechanical, electrical etc.
To summarize, it can be concluded that even making some comparison with what was found from the literature review, there are some similar works or logic. For sure our project will provide something new and improve some of the goals from literature review, the fact is, Using HD camera meaning an output, there will be more details from inputs, even for us sometimes there are problems to manipulate with filters, mounted camera in our project will be the difference on most part of project because they will be on horizontal line with objects as obstacle and the decision. Trying to make an optimal distance, so that the car doesn't stop, but somehow moving forward and analyzing at the same time, by other word this will be smarter.
Although in this work it has not been realized in 3D, but we believe that it helps the reconstruction from the base with 2D. (Yasir Salih and Aamir S. Malik (2012))
Most of industrial application required on 3D, but distance and size of the objects are measured by binocular stereo vision technology. (J H Yang and Q Zhao 2006)

3 Research Methodology

In order to achieve good results, various methods need to be used in order to achieve the objectives. Key methods in this project are inductive. In this project the inputs are the images, but the dealing is just an output, from obtaining data and not just taking a single picture, but in several consecutive patterns. More details are required and naturally it should be collected, and may arise by inductive methods.

Normally considering all those data, it is inevitable that there will be no need to use further methods and analysis techniques since the synthesis and its facts are opposed to each other. It would be definitely useful in both cases, as it provides the possibility to get a lot of information and get to know some of the phenomena that may have occurred during the process.

A comparison method may helpful in this research, because every measurement like distance, high dimension of object as obstacle, width, distance from left side and distance from right side, initially will be measured manually and will be considered like real, afterwards will be compared with respective measurement on real time.

During this work, it is needed to consider every possible situation which clinging to itself and it means that a unique case study is required, to complete and to cover this entire project that will be presented. In more expected situations and in this document various situations will be foreseen and solved in different aspects of study.

The data collected are presented in a tabular and graphical where all possible cases of their analysis are analyzed. Thus, by using statistical and graphical methods it will give a clearer understanding notice the differences in a better manner.

Normally the statistical methods are in some way in relation with mathematics, and in this project it is a must to use both.

In general, all the mentioned methods will be used to calculate details and to present them as clearly as possible, in a way to notice all data which has to be analyzed. (D.-J. Lee, P. Merrell, and Z. Wei. (2010))

4 Results and analyses

Knowing that such works definitely need to have results, as well as authors of this project will try to know that based on the results, is able to fulfill the accuracy of these data. Believing and convinced that through results will be able to describe and recognize the errors despite tests being made. As for closer calculations knowing exact examples and critical points as well as deviations in situations and objects have become better. Some conclusions should be provided, or it will help and guarantee us for the coefficients we have used in code on how effective are, and should intervene in the code again. Based on tests for each situation reports will follow that can explain even results achieved at each point, also while working have some results that do not comply with code but will be explained based on the file named report.log.

Maybe by analysing and calculation results will be significant for all what worked until now, but hoping that based on test and from window which appear during test, there is opportunity to achieve higher accuracy as average. Same time will analysis and all decision has made and to know limits which goes to wrong decision. In other words will define after making comparison of all results to calculate as well as critical sizes.

Figure 1. Assembled Smart Video Car Kit, with additional components

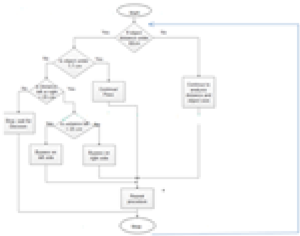

Figure 2. Flow diagram

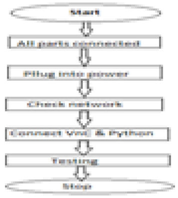

Figure 3. Flow diagram for preparation

Figure 4. Right environment

Figure 5. Vnc viewer

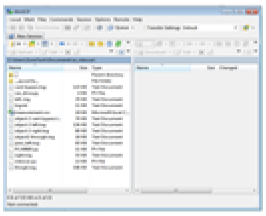

Figure 6. WinSCP

Figure 7. First situation Obstacle under 16 (mm)

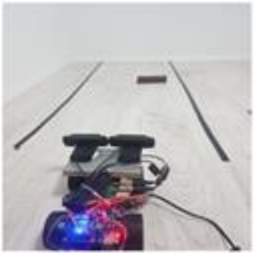

Figure 8. Second situation Bypass left side

Figure 9. Third situation Bypass right side

Figure 10. Fourth situation Can't pass or bypass

Figure 11. Example from appearance on real time from bypassleft side

During test in order to make many measurements and various objects as an obstacle to arrive at a conclusion as accurate as possible. Whether it depends on size of the objects, distance of object, brightness, results were same with other cameras.. On this situation used to review two objects and have calculated and derived the accuracy for each measured parameter.
Selected objects beforehand to meet the conditions initially and did not go to critical point example 16 (mm) is specified in the code and for example object 158 (mm), but objects are much smaller in height as shown above, and finally based on this measurement and accuracy we can come to a conclusion and the critical points where a wrong decision might be taken.
Situations 1 and 4 where car via code makes decision to move forward, it is very easy to achieve, problem was to create code and to make measurements, while in situations where the car has to turn left or right which is described above, the second situation and third situation has been more difficult because its first wheel have too much tolerance.
Thought to put the car in the middle of path and start measuring from one side. May first turn wheel and move forward based on the wheel spin, time and speed were manually measured until it is provided to left path bar, then turn it straight and move forward, even based on these measurements and right side it is same of course with opposite parameters.
Despite this trouble trying many way to get to the end, but during testing have noticed that servo motor compilers that are tasked to rotate in order to push the plastic rod to operate and to turn the wheel has slipped and never was the same split to create the right step that was needed. As to which of situations worked best, can freely say that in general it has a success in all situations, and what have thought and decided in the code that decisions have been made successfully.
the plastic rod to operate to turn the wheel has slipped and never was the same split to create the right step that I needed. As to which of situations worked best, I can freely say that I have had success iin all situations and what I have thought and decided in the code that decisions have been made successfully.
As for the results, can conclude that the goal has been achieved for all situations as well as the various facilities used. After all calculations for object as obstacle 1 and 2, accuracy averacy for both objects is 94.95%.

5 Conclusion

Depending of dimension of object as obstacle, even results are fewer differences which means that object sizes play a role, especially when they are very large.
When working with a servo motor and you have to turn the wheels, set critical limit on code because it can easily damage the indentations.
Based on the application of this project, to continue and to solve fourth situation “cannot pass or bypass”, example if it mounted like in real car can bypass and outside path besides on traffic rules. Or to have additional equipment to jump over it like modular robots.
Project although economically it may be more expensive and more complexity in math aspect, using four cameras would be more accurate cause you have four image from four angles.
On smart embedded system like in our work which is all in real time, must choose microcontroller with high speed rate to transfer data.

6 References

[1] D.-J. Lee, P. Merrell, and Z. Wei. (2010): Two-frame structure from motion using optical flow probability distributions for unmanned air vehicle obstacle avoidance,” Machine Vision and Applications, vol. 21, no. 3, pp. 229-240, 2010.
Citation in text: (D.-J. Lee, P. Merrell, and Z. Wei. (2010))

[2] Ahmed, M. F. (2006):” Development of a Stereo Vision system for Outdoor Mobile Robots," M.S. thesis, University of Florida.
Citation in text: (Ahmed, M. F. 2006)

[3] Yasir Salih and Aamir S. Malik (2012): Depth and Geometry from a Single 2D Image using triangulation, 978-0-7695-4729-9/12, 2012 IEEE DOI 10.1109/ICMEW.2012.95, IEEE International Conference on Multimedia and Expo Workshops
Citation in text: (Yasir Salih and Aamir S. Malik (2012))

[4] Company focused on STEM (2019): Smart Car kit, Raspberry, Arduino and education. https://www.sunfounder.com
Last retrieved 10, 2019
Citation in text: (STEM 2019)

[5] Tsung-Shiang Hsu and Ta-Chung Wang (2015): An Improvement Stereo Vision Images Processing for Object Distance Measurement www.ausmt.org. 86. auSMT Vol. 5 No. 2 (2015), DOI: 10.5875/ausmt.v5i2.460.
Citation in text: (Tsung-Shiang Hsu and Ta-Chung Wang 2015)

[6] J H Yang and Q Zhao 2006 J. Phys.: Conf. Ser. 48 393 (2006): Studies on 3-Dimensional Measurement Using Multi-Images, Institute of Physics Publishing Journal of Physics: Conference Series 48 (2006) 393–397, doi:10.1088/1742-6596/48/1/074 International Symposium on Instrumentation Science and Technology
Citation in text: (J H Yang and Q Zhao 2006)

[7] International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 5, May 2015 Copyright to IJARCCE DOI 10.17148/IJARCCE.2015.4545 199 Implementation of Image Processing on Raspberry Pi K.S .Shilpashree , Lokesha.H , Hadimani Shivkumar. DOI 10.17148/IJARCCE.2015.4545
Citation in the text: (K.S.Shilpashree , Lokesha.H , Hadimani Shivkumar, 2015).

Cost Oriented Control Unit for Robotic Arm

Mitsubishi MoveMaster II

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Abstract. One of the main reasons for robotics development was always making human life easier by assisting or even replacing humans in hazardous environments. But in order to get robotics at that level, a lot of development and research was needed in order to solve the barriers and challenges that appear along the way. Solving problems, especially engineering ones usually accompanied by complex tech which is in most cases expensive to implement, and by that, a new challenge is appearing: high cost. In order to get robotics to help humans, especially in daily tasks, the cost of robotics needs to drop but without affecting its functionality, which is one of the main problems that we will try to solve or at least contribute with our research to help to solve that. In this paper we will focus on developing and implementing a new control unit for an old Mitsubishi MoveMaster II by replacing its old and expensive control unit which is also out of function. For developing such a unit, we will use low-cost parts like L298N motor drive and Xtensa LX7 dual-core microprocessor as main controller. By implementing this controller, not only the overall cost of the robot is reduced but it also became much easier to manipulate with.

Keywords: Low-cost, robotic arm, embedded systems, Xtensa LX7 dual-core.

1 Introduction

The slow pace of the gradual progress in the incorporation of robotics to manufacturing industry is finally coming to an end. Today, six decades after the introduction of robotics in industry which occurred in the early 60s, modern manufacturing, maintenance, services and research is considered incomplete if it does not include robots that execute various functions, communicate remotely and in some cases even improve themselves autonomously. Less costly, more precise and more flexible robot bodies designed for various functionalities are under continuous development. Developers are parallelly working on new control systems as well [1][6]. The effective means of providing both efficient and compatible robotic systems is the topic of concern in this research paper. The paper is focused on a physical implementation; a classic arm has been revitalized by substituting the outdated control module with a new system containing items selected on the basis of cost, without compromising functionality and quality-based goals.

This paper provides a description for the modification and revitalization of a relatively old robotic arm by substituting the control system entirely and creating a low-cost solution using a readily available decommissioned robot and adding other functionalities based on contemporary needs, like remote control through a local wireless network using IoT enabling technologies. In addition, it sets the basis for extensive work in the future, leaving space for new innovative implementations by incorporating even more state-of-the-art technologies. However, the aim of this paper at this point in time is an easy and efficient method to implement a functional remotely controlled robotic arm with six degrees of freedom. We have tried to use the less costly and most easily accessible components and the fastest and easiest ways of programming and configuration techniques.

In the following section of this paper, we will start off by giving a brief description on the aims of the project and expected results. In the third section, there is a review on five case studies concerning the topic of this paper and several other topics that are related to the project in one way or another, all the references are published papers that share the main aim criterion with this project, which is low-cost implementation. The fourth section presents the results including an explanation on flaws and inaccuracies whereas the final section concludes the project by recapping the key points and laying out proposals for future research.

2 Problem statement

During the process of lowering the cost of older robots and making them easier to use by everyone, not only engineers and scientists we need to try to solve problems that are expressed through the following questions:

Can we lower the cost of the old robotic arm just by creating a new cheaper control unit for it?

Controlling small robots with cheaper control units is easy because the hardware part is usually easily compatible with developed software [1]. But if we aim to create controllers for industrial or professional robots like Mitsubishi MoveMaster II, we need to carefully design the control unit so it is not only low-cost but also reliable. Based on this, we will be focusing on finding the best solution to the problem of keeping a balance between affordability and reliability of the control system with this type of robot.

Is it possible to improve the Human-Robot Interface with this new control unit?

If we want to bring robotics into our daily lives, besides lowering the cost we also need to make robots more user-friendly, especially for people who don't have a technical background and when robots have an outdated interface. In order to make this happen, we need to improve the human-robot interface which can sometimes increase the general cost of the robot. We will try to create a software solution in this case by implementing it in cheap but reliable hardware which will be described in the results chapter of this paper.

Can we increase functionality of the robotic arm with new technologies and simultaneously keeping it low-cost?

If we are able to solve the first two stated problems, the third one will probably be easier to address. Basically, by implementing a new control unit for the robotic arm, it gets a technology update that increases its functionality. However, what we want to analyze is whether we can add functions the robot has not had before. In that case, beside the new control unit, the robot would also provide more functionality at a low price.

In this paper, we aim to solve the problems stated above by creating a new control unit, using the latest technology that is available at low cost and then analyzing the results we get.

3 Literature review

Based on the problems we set to solve, we researched related work what others contribute in similar fields. We mostly find that when a cost-oriented robotic arm is included as a topic, authors try to develop both mechanical construction and control unit in order to lower the overall cost of the robot [3]. Other authors try to focus more on the software solutions by developing more complex algorithms without focusing on hardware in order to reduce cost without implementing expensive parts like high-end motors or expensive drivers [5]. Some examples of low-cost research projects are described in the following part of this section in order to give a perspective on what is currently being worked on in this direction.

3.1 State of the art

A worth-mentioning embedded software implementation of a robot localization system has been presented in the IEEE International Conference on Design & Test of Integrated Micro & Nano-Systems held in Tunis, Tunisia in 2019 [2]. A double-core Pandaboard ES with Ubonto 21 operative system as computing unit, a web camera for image acquisition and the RS232 protocol for communication with the robot have been used for the software solution which executes in a parallelized way, where one thread takes care of position detection and the other thread for orientation detection. The image processing algorithm has been implemented in C++ without using the OpenCV libraries.

In an article published in the Elsevier journal [3] a robot arm with two degrees of freedom which is remotely controlled and designed to be used for educational purposes in time of pandemic has been presented. Developers have used an ESP32 microcontroller for internet connection and control which along with two servo-motors is connected to a single 6V power supply. The body of the robot is 3D printed in PLA material. The total cost of this robot adds up to about 60$ per unit.

The paper presented in [4] demonstrates an autonomous low-cost pole climbing robot which is intended to be multi-functional and execute various tasks like cleaning, inspection, surveillance, maintenance and even coconut harvesting in trees. It has been developed using an Arduino Mega 2560 development board, five stepper motors for the robot mechanism and two infrared sensors to detect the top and the bottom of the pole. It can climb upwards and descend downwards thanks to its servo-controlled gripping mechanism.

Raspberry Pi, a low-cost computer is also quite widely used for low-cost solutions in modern era robotic applications. A low-cost automation system for gravity compensation in a robotic arm is presented in [5] where developers have aimed to achieve a better solution for control systems that are based in algorithms which use forward and inverse kinematics. A drawback in these algorithms is the high dependence of the end-effector position accuracy on joint position accuracies. Using the ROS operating system implemented in Raspberry Pi 3, this drawback has been eliminated by applying the gravity compensation technique. The technique has been tested in a 5-degree-of-freedom Kuka youBot manipulator, showing higher accuracy and smaller delay.

A recent publication [6] shows how developers have used the Arduino platform and Arduino IDE for robot control and programming, Bluetooth for wireless communication and a smartphone app created with the open-source simplified online tool AppInventor. The aim was to create a control system for improving the performance of the robot by comparing the 6-degree-of-freedom robot arm motion with a camera image space, identifying errors on each joint through the inverse method for decoupling and then send data remotely for analytics.

4 Results

In the previous chapter, we discussed about the latest developments in the field of low-cost robotics and what other researchers have been working on in the last decade. Unlike other research cases, we have used an old industrial robotic arm instead of making a new one ourselves. The robotic arm used in this project is the Mitsubishi MoveMaster 2 which was developed and released in 1983 by Mitsubishi and came along with a drive unit (40Kb ROM and 32kB RAM, expandable with EPROMs) [7]. Usually, older industrial robots are limited and not very user-friendly, especially in the control part, so replacing the control unit with new ones is usually very expensive. What we aimed to achieve in this paper was not developing a cost-oriented robotic arm from zero but rather functionalizing an existing one by reverse engineering it in order to adapt the new control unit. This has brought possibilities to explore new implementations for upgrading the functionality of the robot. As the main processing unit, we have selected the ESP32 development board for a number of reasons, two of the main ones are wi-fi and Bluetooth connectivity. Two other major advantages are better SRAM (520 KB of SRAM, 448 KB of ROM) and a powerful microcontroller (Dual-Core 32-bit LX7 Microprocessor with clock frequency up to 240 MHz). As a motor driver, we picked the L298 model which has a low cost and is reliable for DC motors. By developing a new control unit, we were able to replace the old control unit which is three to four times bigger in size and uses older technologies that are usually not compatible with today's methods and applications.

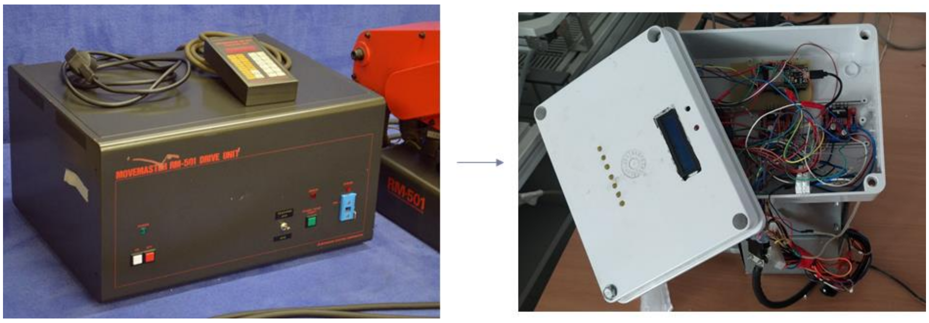

Figure 12. *Comparing the old control unit (on the left) with the new control unit (on the right)*

In the figure 1 the new control unit is shown in an opened enclosure where we can see the ESP32 development board and the motor drivers connected. At the top of the enclosure, we have an LCD panel that shows the IP address used for connecting with the robot, while at the bottom, we can see an old computer's power supply which has been used to power up the entire control unit. An IP address is required to be able to use the IoT feature of EPS32 and developed. We have also created a web-based interface which makes it much easier to control the robotic arm via smartphone, tablet, or PC/laptop simply by connecting it to the IP address shown on LCD screen.

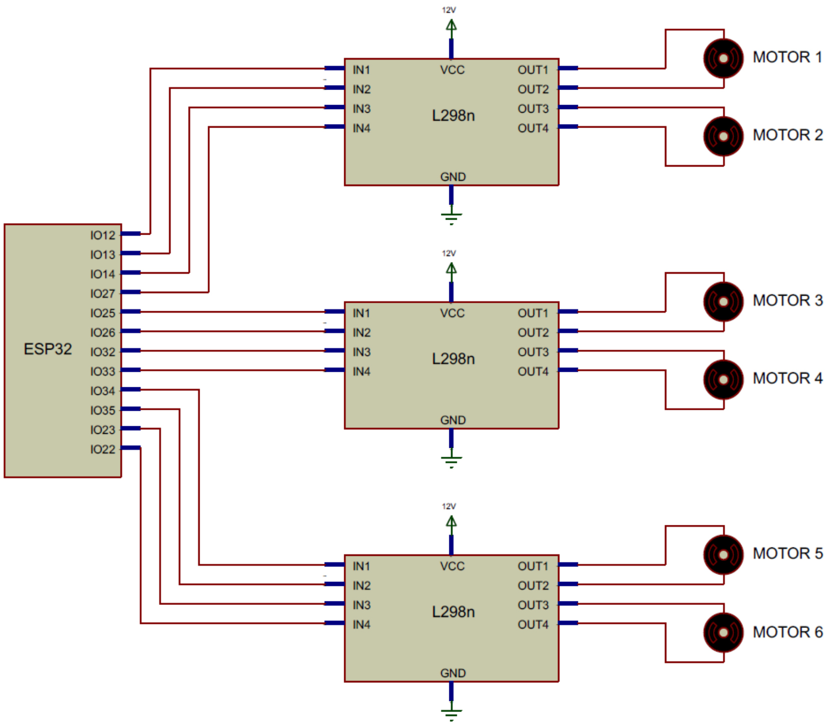

Figure 13. *New control unit circuit*

In figure 2 we can see the circuit of the drive which is inside the enclosure. Every motor is controlled individually through L298N drive which can control the direction and the speed of the motor. In the end, every drive is connected to EPS32 which is the main processing unit for each motor drive and consequently for each motor.

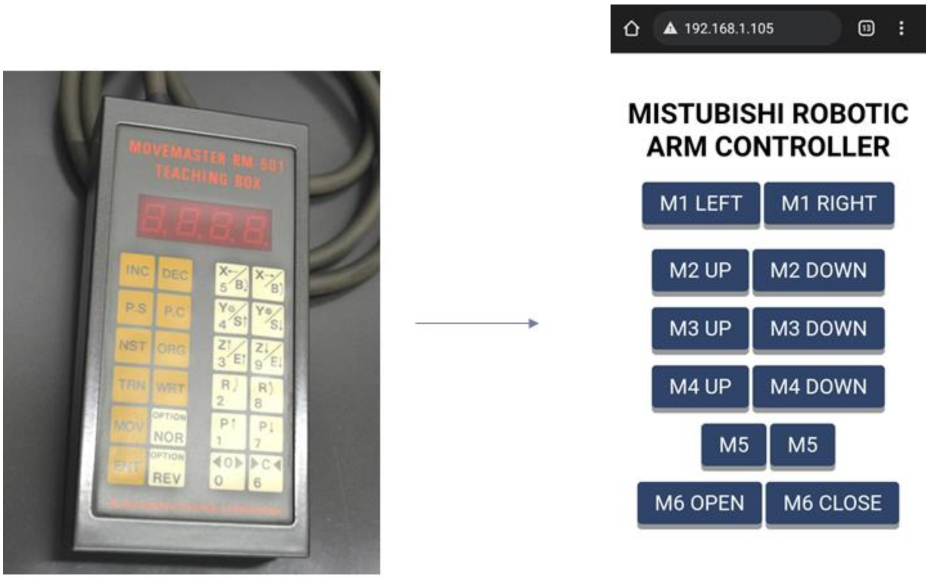

Figure 3. *Old control interface (on the left) vs new web-based control interface (on the right)*

As we can see in figure 2, the new interface gave us full control of each motor and it is much easier to understand which motor you are controlling and in which direction. Also, it makes it possible to control the robot wirelessly, thus not limiting us in the aspect of distance and mobility.

After successfully implementing the new control unit and interface we tested functions of the robot such as accuracy and repeatability. After several tests, we notice that there is a slight issue with repeatability. Unfortunately, the old control unit of the robot is not working at all, so there is no possibility to compare the movement data from the old one.

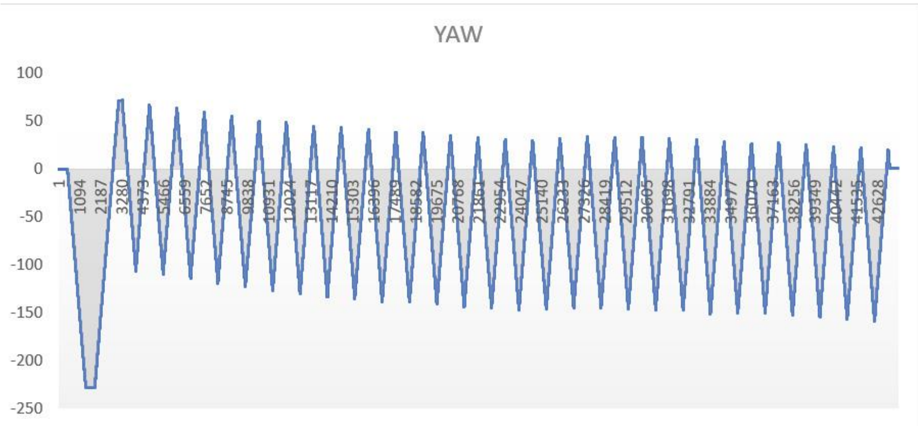

Figure 4. *Measured data of YAW angle from external gyroscope in robotic arm*

We placed an external gyroscope at the top of the robotic arm and then programmed the robot to repeat the same movement for several minutes. By tracking movements through the gyroscope, we can see the spikes in the diagram, that represent an end-to-end position of the robot during movement. As can be noticed, they shift slightly after each period, this implies that the robot is not stopping at the same position on each step even though we programmed it to behave that way. The main reason behind this unwanted behaviour is that we did not use the motor encoders due to lack of documentation on schematics of the robot, which made it impossible for us to find the connection of the motor encoders. Repeatability will most likely improve significantly if encoder data is added to the control system because with data from encoders, we can know the exact position of the motor and as a result of the robot also.

Now if we compare the cost of a new control unit which is shown in figure 1 (the right one) with the old control unit (the left one) we can see a noticeable difference. A new control unit including all components we mentioned cost around 40€. On another side, the old control unit, unfortunately, isn't in sale anymore because the robot is not produced anymore. But there are still online sellers that sell used old control units and the price is around 600€ to 700€ and when you add shipping cost it goes usually more than 1000€ (shorturl.at/wBHLT). So, besides the fact that we can lower the price by implementing a newly developed unit compared to buying the used one, it is also much more practical in many aspects like size, usability, functions, etc.

5 Conclusions

This research paper recommends lowering the cost of robots by developing a new control system. As robots are usually modular and are compatible to various types of parts, achieving this purpose is most of the time feasible and can be done with a relatively low effort. We have used a Mitsubishi MoveMaster II robot to demonstrate a working model that successfully achieves this goal. Our approach is to substitute the outdated control system with a contemporary one by using ESP32 development module which is based on an Xtensa LX6 microprocessor. Furthermore, we have added functionalities like robot control via a smartphone app using IoT enabling technologies. This approach resulted in a working system with an exceedingly acceptable performance, although repeatability issues have been observed while testing the system. Besides that, we see in the results that difference in cost between new control unit and old used one is something between 550€ to 950€.

Advancing the control system so it fully complies to the industry standards is our main recommendation for future work. Nevertheless, industrial robots require high reliability, therefore it is imperative that extra care is taken when intervening in their physical structure and programmatic functionality. For this reason, balancing low-cost and reliability would add to the complexity of this process. Moreover, we also recommend working on a user-friendly version by applying software solutions as robots provided for everyday use that will be managed by users that lack sufficient knowledge in robot operation are becoming ever more present in the market. Finally, the modular construction and programmability offers potential in adding a number of other functionalities, including machine learning capability.

1 References

[1] S. Hussmann, F. J. Knoll, A. Meissner and T. Holtorf, "Development and evaluation of a low-cost delta robot system for weed control applications in organic farming," in *2019 IEEE International Instrumentation and Measurement Technology Conference (I2MTC)*, Auckland, New Zealand , 2019.

[2] N. B. Amor, M. Baklouti, K. Barhoumi and M. JALLOULI, "Efficient embedded software implementation of a low cost robot localization system," in *IEEE International Conference on Design & Test of Integrated Micro & Nano-Systems*, Gammarth, Tunisia, 2019.

[3] V. H. Benitez, R. Symonds and D. E. Elguezabal, "Design of an affordable IoT open-source robot arm for online teaching of robotics courses during the pandemic contingency," *HardwareX,* vol. Volume 8, 2020.

[4] H. Khairam, Y. M. Choong, N. S. N. Ismadi, W. A. F. W. Othman and A. A. A. W. a. S, "Design and development of a low-cost pole climbing robot using Arduino Mega," in *Journal of Physics: Conference Series,* 2021.

[5] W. Montalvo, J. Escobar-Naranjo, C. A. Garcia and M. V. Garcia, "Low-Cost Automation for Gravity Compensation of Robotic Arm," *Applied Sciences (Switzerland),* vol. 10, no. 11, 2020.

[6] Y. Zhu, Z. Wu and C. Liu, "Six-degree-of-freedom manipulator wireless control system based on Internet of Things," *Journal of Ambient Intelligence and Humanized Computing,* 2021.

[7] "MSX," Microcomputer & Related Culture Foundation, 28 June 2021. [Online]. Available: https://www.msx.org/wiki/Mitsubishi_Move_Master_II_RM-501. [Accessed 10 2021].

The challenges of industrial automation in manufacturing companies in Kosovo

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Abstract. In the century in which we are living every sphere of life is moving towards automation and digitalization as well as the production of products and the creation of services. Industrial automation and the application of digital technology are opportunities but also challenges. This research was conducted in manufacturing and service companies in Kosovo. How many opportunities do automation companies give you and what challenges have they faced, Also in this research are analyzed how much knowledge companies have, for the new technologies that are applied such as: Industry 4.0, AI (artificial intelligence), ML (machine learning), 3D printer, ‘Cloud’ technology, VR (virtual reality).

Keywords: Automation, Industry 4.0., Digital technology.

1.INTRODUCTION:

Nowadays everything is moving towards automation. Digital technologies and automation are opportunities but also a challenge for the companies that use it. This topic has been chosen for research as there is little research of this nature in Kosovo and investments in automation still need to be made.

This paper reviews the literature on automation in general, the challenges of implementing automation and the opportunities that automation offers to companies that use it. The purpose of this study is to provide an in-depth analysis of the level of digital transformation (automation) of manufacturing enterprises in Kosovo and to research the views of their managers on the most important driving forces and obstacles to the implementation of automation.

The research topic is based on the automation challenges faced by Kosovar companies in the age of digitalization. But in addition to these challenges is the opportunity to create a competitive advantage in the market over other companies. In addition to the challenges, this paper will address the possibility with the research question: How has automation influenced the industry to have a competitive advantage?

Automation in the manufacturing industry has evolved from the use of basic hydraulic and pneumatic systems today's modern robots. Most industrial operations are automated in order to increase productivity and reduce labor costs. From the beginning industrial automation has made great strides among activities that were previously performed manually. A manufacturing enterprise that uses the latest technologies to fully automate its processes typically sees improved efficiency, the production of high-quality products, the reduction of manual work, and the reduction of production costs. (Lamb, 2013).

2.Industrial automation

Industrial automation is a multidisciplinary discipline that includes knowledge and expertise from various engineering sectors, such as electrical, electronic, chemical, mechanical, communication, control, and software engineering. Nowadays, the application of industrial automation has become a ubiquitous infrastructure that automates and improves daily life. Typical examples of industrial automation systems can be found in the automotive industry, the aviation sector, the maritime industry, the healthcare industry, rail transport, electricity generation and distribution, the paper industry, and many other applications. Our society has become so dependent on automation that it is hard to imagine what life would be like without engineering automation. With current developments in the field of industry 4.0, industrial automation has been unified with the concept of the Internet of Things, interconnected systems and physical-cybernetic systems, in order to create a vision-integrated ecosystem to enable clean automation for all aspects of life, for a future in which everything will be connected, integrated and automated.

Nowadays, the concept of automation in an industrial production process is a very attractive topic for electrical engineers, because it perfectly combines all the principles and methods of classical automatic control with microcomputer or microprocessor technology. The introduction of microcomputer technology in the field of industrial production, coupled with the development in the field of robotics, resulted in the creation of a special scientific field known as "automation and robotics". Although this field seems to be separate from "automatic control", this is mainly due to its great scope and not to the differentiation of its theoretical principles. The rapid development of automation and robotics in today's technological world has made it necessary for some time to place industrial automation and robotics courses in the curriculum of various departments of electrical and computer engineering. Each industrial production process consists of a series simple or complex machine through which the raw material undergoes a subsequent treatment to achieve the production of a final product, while fulfilling the goal of increasing production, improving product quality, reducing costs and increasing production flexibility. Initially, industrial automation systems were implemented in a conventional manner, i.e., with specific independent equipment (timers, counters, auxiliary relays, etc.), and their installations in accordance with the desired mode of operation. Today, the implementation of an industrial automation system is done on specific digital devices called programmable logic controllers (PLCs). The main feature of PLC technology is the need for programming (versus wiring) industrial system control logic. The many advantages of PLCs have made them the main tool for controlling an industrial system, but also for other non-industrial systems we encounter in our daily lives, such as traffic control for a road junction, a building elevator. , an automatic car wash, etc. (Manesis & Nikolakopoulos, 2018)

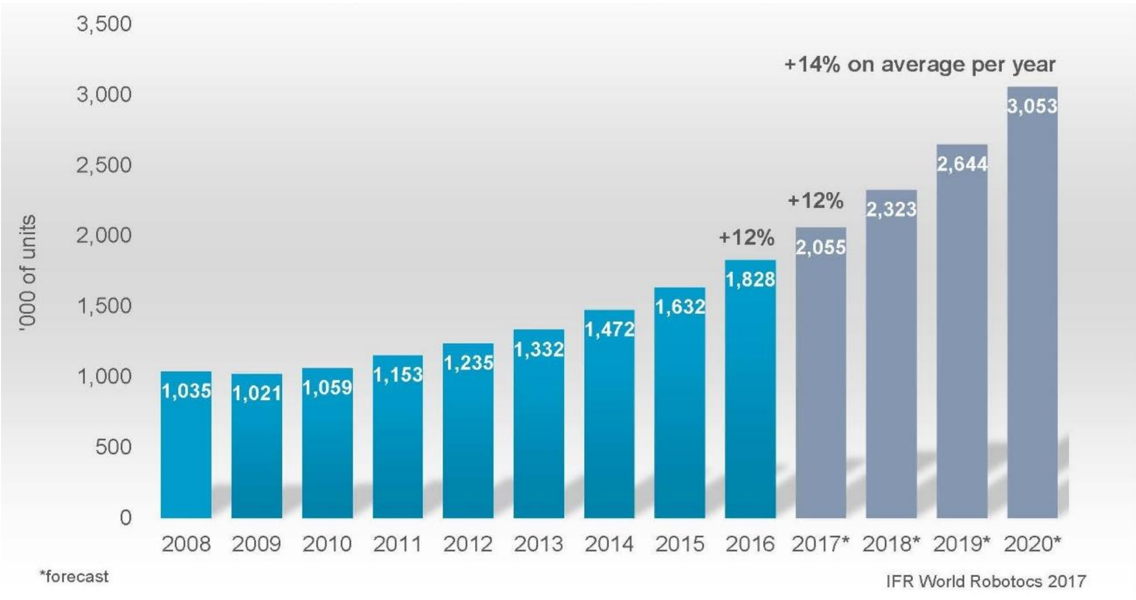

Figure 1 Use of industrial robots in the world (IFR, 2018)

3.Results:

Automation has had a positive impact on the entire production process of enterprises. It has also had a positive impact on competition in the market by enabling you to create a new product / service, reduce production costs, increase productivity, efficiency and effectiveness. However, the biggest challenge of automation for enterprises in Kosovo is the high cost of financing for production technologies, then the lack of skilled staff for the use of these technologies and the lack of business policies for institutional support.

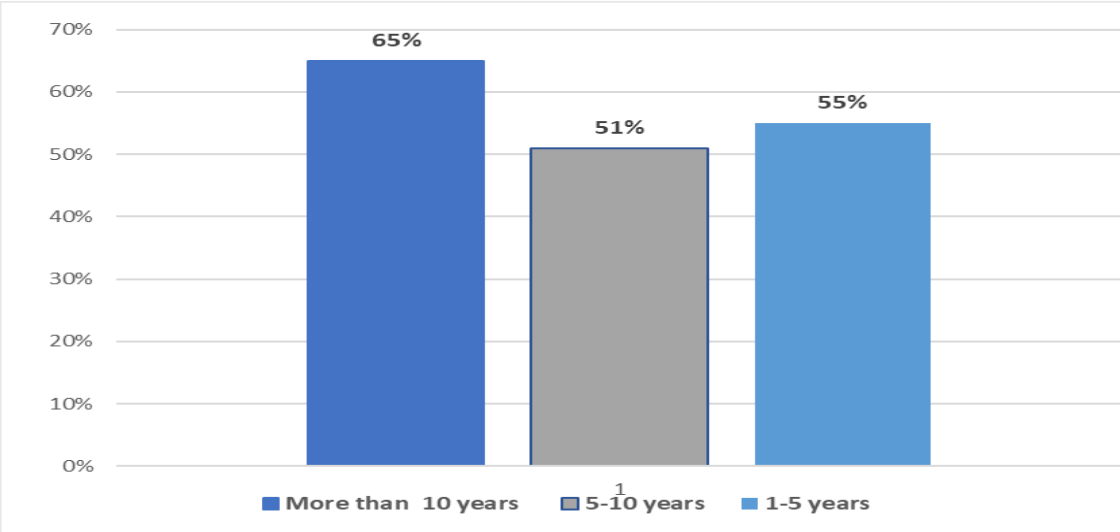

Figura 2 The level of automation

In fig.2. the level of automation is presented depending on the year of establishment of the company and as noted in companies which are older than 10 years the level of automation is 65% is higher than the overall average of the automation level which is 58%.

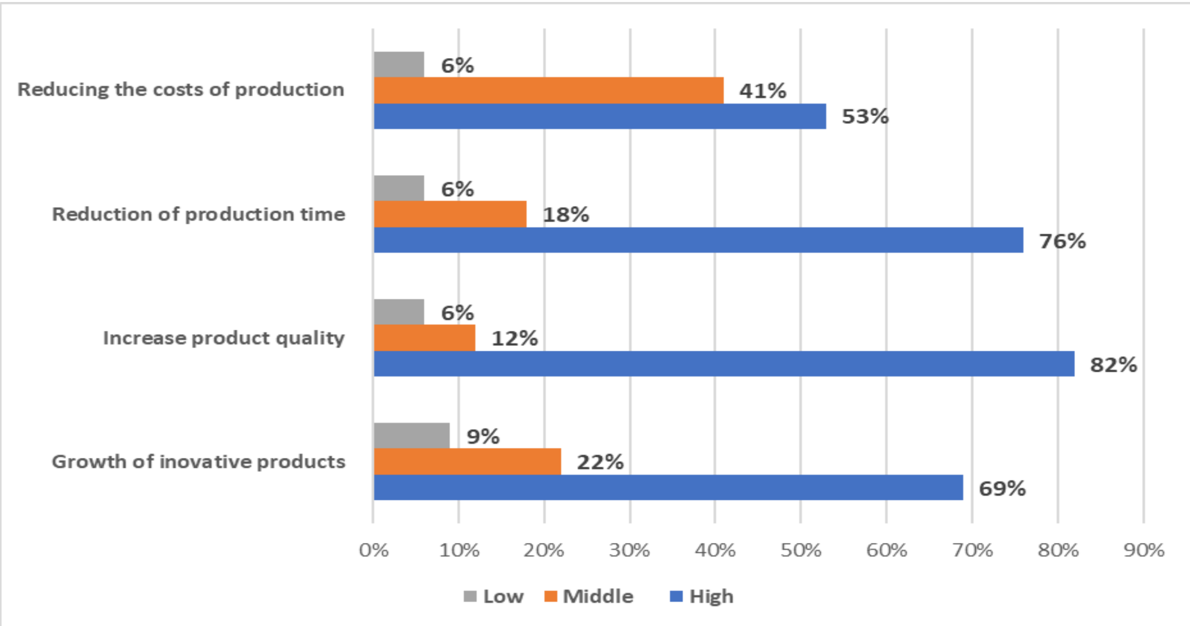

Figure 3 The impact of automation on the industry to have a competitive advantage in the market

In fig.3. the impact of automation to have an advantage in the market is presented. As can be seen, automation has a high impact on increasing the quality of production and reducing the production time of a product. As for the cost of production the percentage is lower because companies have to invest a considerable amount of assets in the beginning and therefore we have a lower percentage. While in the case of innovative products most companies think it is easier to produce a new product with new technologies.

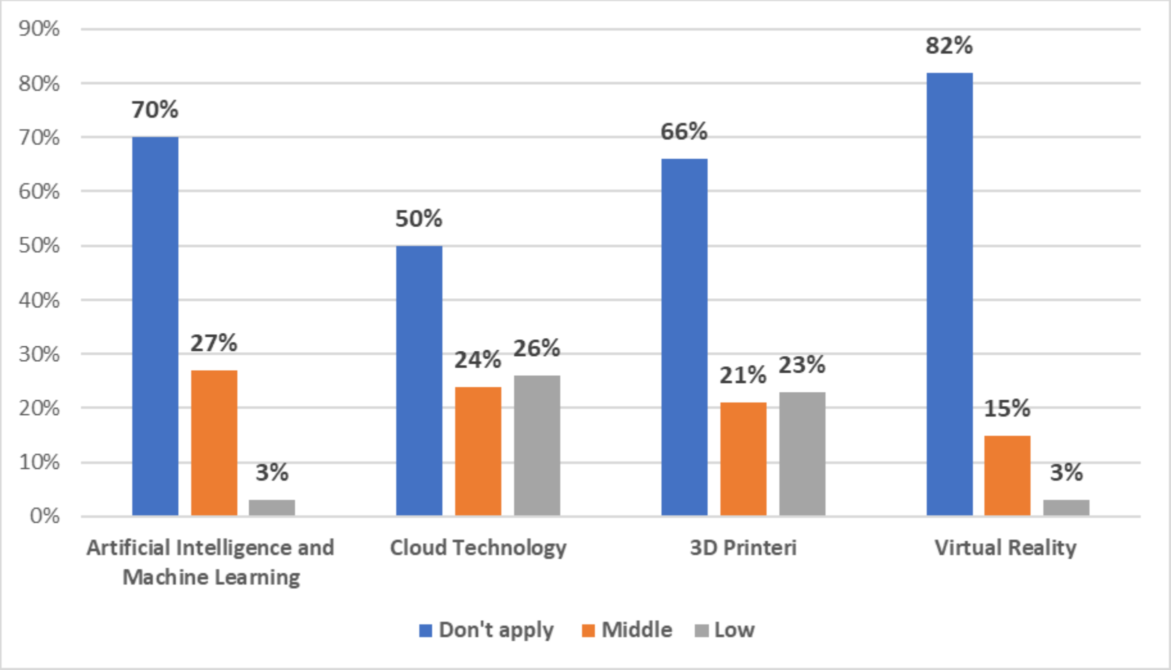

Figure 4 Level of use the digital technologies

Figure 4 shows the level of application of digital technologies, it is noticed that the level of application is very low which shows that the knowledge of these technologies is not at the right level. Newer technologies such as: virtual reality, artificial intelligence and machine learning find very little application in our companies which shows that with trends in technology still need to make higher investment and start applying them.

4.Conclusions:

Technology has made great revolution in every field of life. What is noticeable is that with the advancement in technology to stay in the market (competitor) is what companies most adapt to the changes and trends of new technology.

-Automation and new technologies have made: to reduce the production time of products, to have higher efficiency, efficacy and productivity, to offer new products and services and also to create new sales bridges with customers around the world.

In terms of use and knowledge about new technologies such as: Artificial intelligence, 'machine learning', Virtual Reality, 3D Printer, Cloud technology level is not very satisfactory, very few find application in our companies which shows that with the trends in technology a higher investment still needs to be made and started to apply.

Reference:

Manesis, S., & Nikolakopoulos, G. (2018). Introduction to Industrial Automation. In Introduction to Industrial Automation. https://doi.org/10.1201/9781351069083

Lamb, F. (2013). Industrial Automation: Hands On. McGraw-Hill Education. https://books.google.com/books?id=H977GaxHwaAC

IFR. (2018, May 30). *Robots double worldwide by 2020 - International Federation of Robotics*. https://ifr.org/ifr-press-releases/news/robots-double-worldwide-by-2020

Limani, Y. (2018). Automatizimi i Prodhimit dhe Prodhimi i Integruar me Teknologji të Informacionit. UBT

Martin Luenendonk. (2019). Industry 4.0: Definition, Design Principles, Challenges, and the Future of Employment | Cleverism. https://www.cleverism.com/industry-4-0/

Olsson, J. G., & Yuanjing, X. (2018). Title: Industry 4.0 Adoption in the Manufacturing Process. Multiple case study of electronic manufacturers and machine manufacturers.

Errors in Distance and Angle Measurements of Ultrasonic Sensor HC-SR04

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Abstract. This project presents the measurement of distances and angles by means of Arduino Uno microcontroller and Ultrasonic Sensor HC-SR04. Accuracy on distance and angle measurements of the sensor has been investigated. The change of object distance in motion is displayed and monitoring of the change of the angle and position. Data measurements were compared with the real measurement unit of the meter to observe their deviation, 1.6% of the standard deviation is observed between real measurement and sensor data, meanwhile, at the angle data measurements were no deviation is observed.

Keywords: Measurement errors, Measurement uncertainty, Arduino Uno, Ultrasonic sensor.

Introduction

As ultrasonic sensors become more common, sufficient testing is imperative. The HC-SR04 is the most common type of sensor taught in schools, as it comes with every Arduino Kit, but there's a lack of testing done on this sensor. This sensor is based on the principle of measuring the time from sending and receiving an ultrasound chirp. [1]. This principle ensures accurate measurement of bodies, regardless of their colour or their surface type - this allows to measure the distance of transparent materials such as glass and water. Ultrasonic sensors are produced in different types; sensors for laboratory use are simpler, with only a transmitter and receiver together in the chassis, while for industrial use we have more robust types, with metal chassis and with multiple receivers and transmitters. Some types allow you to change the sensitivity of the sensor by means of a potentiometer. We also have sensors with a direct connection to a computer, where all sensor parameters can be changed, from the maximum amplitude of the waves up to the mode of delivery of measurements [2]. Ultrasonic waves have the same propagation characteristics as sound - all frequency sound waves higher than 20 kHz are classified as ultrasonic waves. [3]. The HC-SR04 ultrasonic sensor, also known as a sonar is an obstacle sensor. It measures up to 4 [m]. The sensor starts by sending an electrical charge from the microcontroller to the Transmitter, which lasts at least 10 [μs] [microseconds], in response to this electrical charge the sensor sends 8 ultrasonic pulses with a frequency of 40 [kHz]. This transmission method enables the pulse sent by the sensor to be distinguished from ambient noise, and to not receive the wrong ultrasonic pulse. After receiving 8 ultrasonic pulses, the Receiver switches to HIGH, and starts waiting for the return pulses for 38 [μs]. If the pulses do not return within 38 [μs], this means that at 4 meters that the sensor can measure, there is no obstruction and the Receiver switches to LOW. If the pulses return, the Receiver switches to LOW immediately and produces an electrical charge depending on the time elapsed since the electrical charge was sent by the Transmitter.

To measure distance, we take the distance formula:

$$Distance = \frac{Velocity}{Time} \tag{1}$$

by substituting the electric charge received in microseconds [μs] in time, and constant speed of sound in the air $0.034\ \left[\frac{cm}{\mu s}\right]$ is found the total distance from sending the signal to receiving it. To find the distance from the obstacle to the sensor you must divide the total distance by 2 [4]. Ultrasonic sensor pins should be connected as follows, pin VCC, connects to Arduino VCC. Supplies the sensor with 5 [V] Pin Trig, or Trigger, is used to "shoot" ultrasonic waves from the sensor. Pin Echo, produces an electrical charge when the reflected signal is received. The signal amplitude is proportional to the time elapsed since the signal was sent and received. Pin GND, connects to the GND pin on the Arduino [4]. Our code is template, as it consists of only an ultrasonic sensor, a notable part is the Newping library, which increases our accuracy:

```
#include "NewPing.h"
#define TRIGGER_PIN 9
#define ECHO_PIN 10
NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);
float duration, distance;
int iterations = 5;

void setup()
{
        Serial.begin(9600);
}

void loop()
{
        // Send ping, get distance in cm
        duration = sonar.ping_median(iterations);
        distance = (duration / 2) * 0.0343;
```

```
        Serial.print("Distance = ");

        if (distance >= 400 || distance <= 2)
        {
                Serial.println("Out of range");
        }
        else
        {
                Serial.print(distance);
                Serial.println(" cm");
        }
        delay(500);
}
```

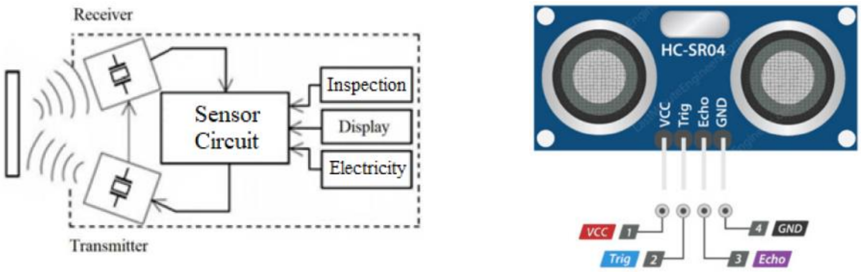

Fig. 14. Sensor block diagram and HC-SR04 ultrasonic sensor (Source: https://lastminuteengineers.com/arduino-sr04-ultrasonic-sensor-tutorial/)

We wanted to compare the results we got from our Arduino IDE system to something more practical, so we choose LabVIEW since it is very commonly taught and used in industrial settings. Our virtual instrument base was LINX, as it made our setup very simple.

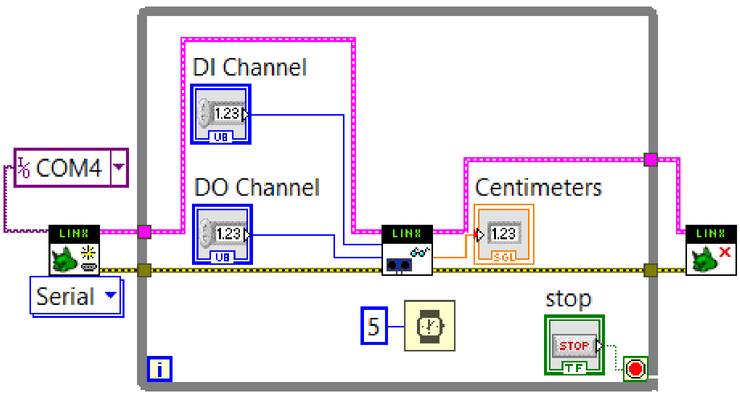

Fig. 2. Block diagram prepared in LabVIEW

Research method

We decided on 200 cm being our maximum distance, as beyond that our readings were becoming too erratic.. The sensor was placed on a horizontal position, by facing only the wall while moving away from it to reduce large fluctuations in measurements due to the sensor not sensing a smaller object. Measurements were done in room temperature, respectively 18˚C. Instead of only measuring the wall, an opaque object, we also chose a sheet of glass, as it was transparent, to see if there's a difference.

We proceeded to move away from the wall every 25 cm. All these measurements were done in reference to a Class II European tape-meter. The following table shows the maximum error of possible for each distance value according to the standard European class II tape meters.

Table 1. Meter measurement errors

Maximum errors by standard					
1m	2m	3m	5m	8m	10m
$\pm\mathbf{0.5}$	± 0.7	± 0.9	± 1.3	± 1.9	± 2.3

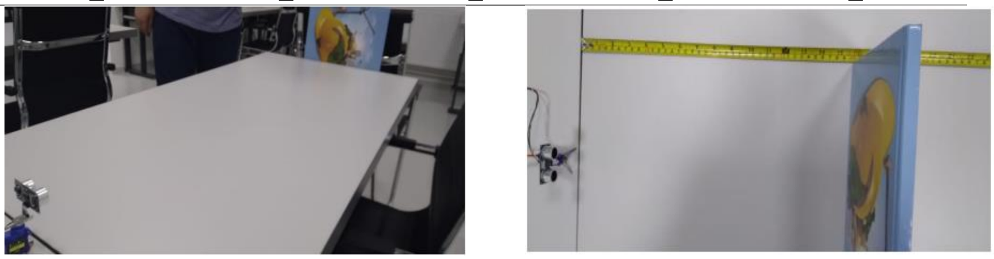

Fig. 3. Taking the reference distance from the meter using a smaller object such as a notebook

Results

Table 2. Rinor's sensor data for distance testing. All measurements in [cm]

Distance	Meter Tolerance	Arduino IDE	LabVIEW	Error ARD	Error LabVIEW	Total ARD	Total LabVIEW
25	0.5	24.88	24.603	0.12	0.397	0.62	0.897
50	0.5	49.1	48.47	0.9	1.53	1.4	2.03
75	0.5	74	73.196	1	1.804	1.5	2.304
100	0.5	98.02	97.71	1.98	2.29	2.48	2.79
125	0.7	123.39	122.89	1.61	2.11	2.31	2.81
150	0.7	148.16	146.7	1.84	3.3	2.54	4

175	0.7	173.06	171.32	1.94	3.68	2.64	4.38
200	0.7	198.17	195.43	1.83	4.57	2.53	5.27

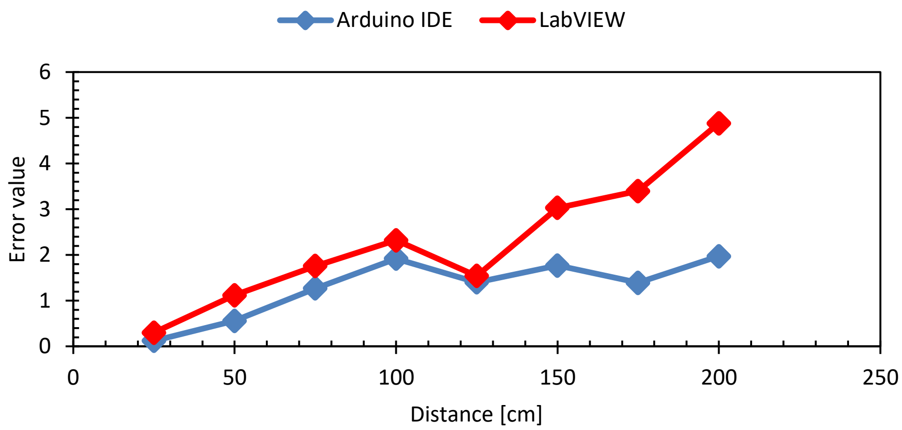

Fig. 4. Rinor's sensor errors, graphed and compared for both systems

Table 3. Plotdon's sensor data for distance testing. All measurements in [cm]

Dis-tance [cm]	Meter Tolerance	Ar-duino IDE	Lab-VIEW	Error ARD	Error Lab-VIEW	Total ARD	Total LabVIEW
25	0.5	24.88	24.7	0.12	0.3	0.62	0.8
50	0.5	49.44	48.88	0.56	1.12	1.06	1.62
75	0.5	73.73	73.24	1.27	1.76	1.77	2.26
100	0.5	98.08	97.68	1.92	2.32	2.42	2.82
125	0.7	123.6	123.46	1.4	1.54	2.1	2.24
150	0.7	148.23	146.97	1.77	3.03	2.47	3.73
175	0.7	173.61	171.6	1.39	3.4	2.09	4.1
200	0.7	198.03	195.12	1.97	4.88	2.67	5.58

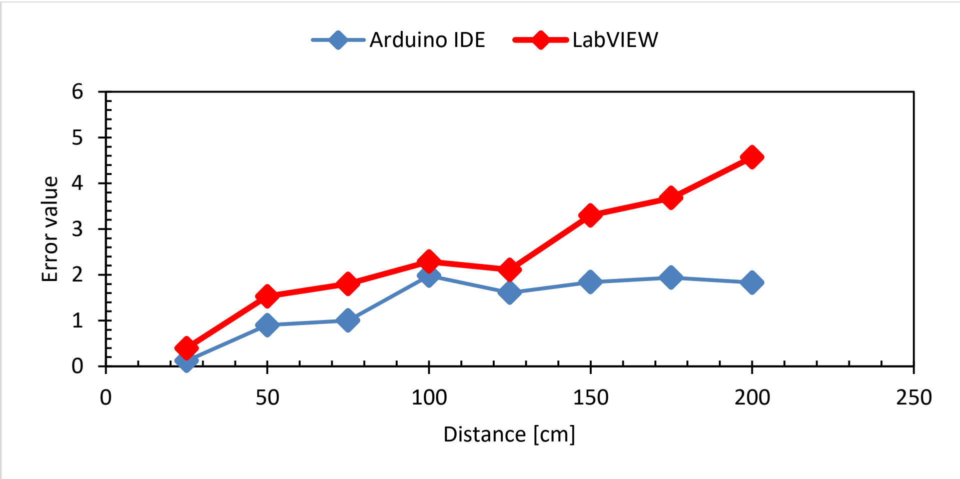

Fig. 5. Plotdon's sensor errors, graphed and compared for both systems

Table 4. Transparent body measurements. All measurements in [cm]

Distance	Meter Tolerance	Arduino IDE	Lab-VIEW	Error ARD	Error LabV	Total ARD	Total LabV
50	0.5	48.14	48.5	1.86	1.5	2.36	2
100	0.5	98.74	97.42	1.26	2.58	1.76	3.08
150	0.7	148.16	146.43	1.84	3.57	2.54	4.27
200	0.7	197.62	195.23	2.38	4.77	3.08	5.47

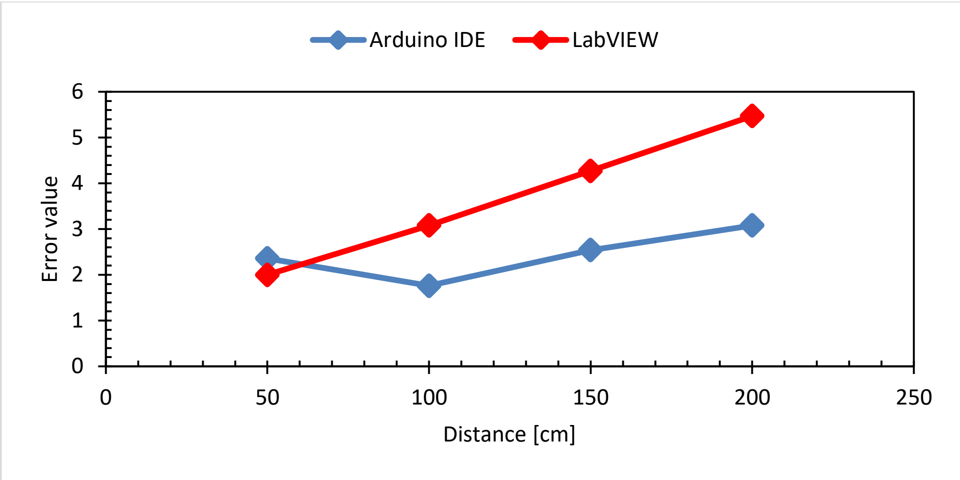

Fig. 6. Transparent body errors, graphed and compared for both systems

We read the corresponding tape-meter tolerance, and we take the maximum deviation of up to 2 meters which is obtained by taking the maximum total error and dividing by our maximum distance:

$$P_S = \frac{\max(|\Delta_S| + |\Delta_M|)}{300} * 100\%$$

For Rinor’s sensor it came out to be 1.32 % for the Arduino IDE system, and 2.635 % for the LabVIEW system. For Plotdon’s sensor it came out to be 1.335 % for the Arduino IDE and 2.79 % for LabVIEW. Meanwhile for our transparent object 1.54 % for the Arduino IDE and 2.73 % for LabVIEW.

Angle measurements were compared to manufacturers data, that is, 15˚. To test this feature, we took measurements from a set distance , it being 100 cm away from the ultrasonic sensor.

Then by means of a measuring object, in our case a sheet of metal, we moved from left-right, and right-left until the sensor captured the signal. The moment we received the data from the sensor, we measured the hypotenuse using the tape-meter. By simple trigonometry, we find the closing angle between sensor measurement and hypotenuse taken from the meter.

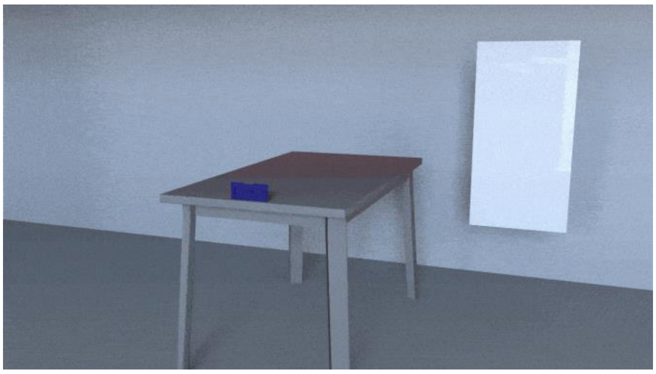

Fig. 7. The measuring object on the left and the right side

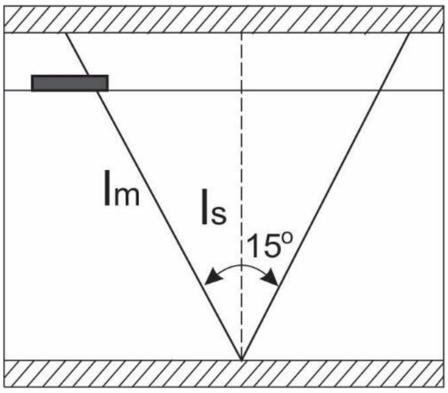

Fig. 8. The principle of measurement https://www.sciencedirect.com/science/article/pii/S2405896316326623

Table 5. Distances and angle calculated for Rinor's sensor

	Hypotenuse	Adjacent	Angle
Right	100.3	100	5.71
Left	101	100	8.069
			≈ 13.779

Table 6. Distances and angle calculated for Plotdon's sensor

	Hypotenuse	Adjacent	Angle
Right	101.05	100	8.26
Left	101.6	100	10.18
			≈ 18.44

Conclusion

Practical measurements reveal that the HC-SR04 sensor measures distance with high accuracy. In measurements of up to 200 [cm], the accuracy of measurements was up to 1.54 [%] for our transparent object, which fits with the manufacturers data. The accuracy of measurements was generally dependent on the distance to the object. Our LabVIEW system was much worse compared to our Arduino IDE system. For larger distances, Plotdon's sensor was more accurate than Rinor's sensor. Compared to the documentation, our angle differed by 2-3˚, which is acceptable. For accurate measurements, avoid LabVIEW, reduce air flow and avoid extreme temperatures.

References

[1] J. Smoot, CUI Devices, 1 April 2021. [Online]. Available: https://www.cuidevices.com/blog/the-basics-of-ultrasonic-sensors. [Accessed 12 11 2021].

[2] E. Kevin, Dittman & Greer, Inc., 2007. [Online]. Available: http://www.dittman-greer.com/news/2007-winter/3-tech_ultrasonic.htm. [Accessed 12 11 2021].

[3] R. E. (. Berg, Britanica, 6 10 2017. [Online]. Available: https://www.britannica.com/science/ultrasonics. [Accessed 10 11 2021].

[4] L. M. Engineers, 18 December 2020. [Online]. Available: https://lastminuteengineers.com/arduino-sr04-ultrasonic-sensor-tutorial/.

3D Digital Measurement of Dimensions, Displacements, and Deformations of the Parts

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Abstract. The 3D digital measurement is commonly used nowadays when parts are with complex geometry, and fast development is required. This comes also from constant technological improvements of devices like 3D scanners. However, the use of them for particular applications needs research that shows the wide range of usability. The purpose of this study has to do with better understanding of the measurement of dimensions, displacements, and deformations of the parts using non-contact techniques, which are elaborated with the case studies for each investigation. Base on the presented research, we see the approach of using the 3D scanning technique for several applications. From a general point of view, we conclude that the use of 3D digital measurement is a useful and flexible methodology for different parts, shown by the presented work. Future research should deal with improvements that are required in terms of the integrated measurement approach.

Keywords: 3D digital measurement, Dimensions, Displacements, Deformations, 3D scanner.

1 Introduction

In recent years, there is a constant need for advanced interaction between physical reality and digital data. This comes mostly from the new need for rethinking of design and new product development in general [1]. New design and manufacturing technologies [2] move the frontiers toward new open ways about the measurement techniques. In this context, several technologies are relevant for this interaction, including reverse engineering [3], additive manufacturing [4], CNC machining, etc. Generally, the inspection process and quality control were a constant requirement from several aspects of industrial part applications. There are several issues that are required, specifically in dimensional inspection, displacement and deformation. In previous, the contact measuring techniques were very obvious for use in different applications. On the other side, non-contact measuring techniques are very common

nowadays [5, 6]. They are flexible both in integration with other systems and also in capturing data from complex geometries.

Due to actual measurement technologies, there is a need to bring this research in a broad context with the importance of more clarifying the relationship and possibilities of 3D digital measurement in different aspects. The purpose of the work has to do with better understanding of new optical techniques for the measurement of dimensions, displacements, and deformations of the parts. The significance of the research stands in presenting the actual work and showing the gap for the integration approach.

The paper will review research works on the subject in Section 2, while in Section 3 the case studies from dimensions, displacements, and deformations of the parts will be presented. Finally, the conclusions will derive the actual situation and further work.

2 Literature Review

Given the aspects of using advanced measuring technologies in different industrial sectors, it is worthy to search from scientific work contributions. There are several important factors which need to be addressed, including scanning factors, the reflection of material and coating, the scanning strategy and reflection, and the shape of the parts.

Gerbino, Del Giudice et al. [7] have investigated some important factors that influence the measured data from the 3D scanner. They can be divided into external and internal. From external can be included, ambient lightening and sensor to surface relative position. From internal, accuracy, and scanner resolution. Those factors were tested in the sheet metal complex part. The accuracy of the process is depended more on the scanner-to part relative orientation, and position of the device.

Mendřický [8] has shown the coating aspects in relation to quality and accuracy of 3D measured parts with different coating thicknesses and has elaborated seven matt coating products, which are used daily for practice. From collected results, the way how to use coating in products, as well as the removal of it, are presented.

Pereira, de Lima e Silva Penz et al. [9] have presented the research that deals with the reflection of the surface of translucent parts during optical scanning. They proposed to use gold, silver, platinum, and carbon for coating and compare them with traditional ones to evaluate the results. From the collected data, the proposed coatings offer higher accuracy and are suggested for 3D scanning.

Koteras, Wieczorowski et al. [10] have treated the impact of optical measurement strategy and its relation with accuracy, especially in big parts. The idea was to test the structure light device to measure the part with dimensions out of the capacity limits. Here several measurement strategies were investigated, while the strengths and weaknesses are concluded.

Cuesta, Alvarez et al. [11] explained the work which deals with both laser scanners and coordinate measuring arms for dimension and tolerance inspection. Related to this, a comparison was made between them. The study shows that is needed to use the right scanning strategy that can cover any surface, and on another side, the use of

statistical analysis with several measurements to complete the feature-based gauge.

Guidi, Malik et al. [12] have used the 3D scanning technology to measure the part with relatively big dimensions and specific geometry, which proves the flexibility of using this technique.

Eastwood, Zhang et al. [13] presented the possibilities for fully automated measuring and inspection of parts using a photogrammetric process. This also comes from the ability to be accessible in parts with complex forms produced by additive manufacturing.

Guerra, De Chiffre et al. [14] have shown the procedure of testing the different 3D scanners technologies including structured light, laser line, and photogrammetry scanner, which are common techniques for inspection in different applications, including additive manufacturing.

Sedlak, Hrusecka et al. [15] have presented the use of reverse engineering technology as the tool to inspect the specific feature of the part and make the data comparison and analysis.

3 Application using Case Studies

In this section, we are focused to explain the applications of 3D digital measurement technology in different aspects including dimensions (section 3.1), displacements (section 3.2), and deformations (section 3.3) of the parts. Today, there are different fields where this technique is applied, especially in parts produced by additive manufacturing [16-18]. Moreover, it is a good way of moving forward in terms of integration using a digital chain between advanced manufacturing technologies and 3D optical devices. The presented case studies are detailed elaborated in [19].

3.1 Dimensions

The most common application of 3D digital measuring techniques among others is related to dimensional check. There are certain aspects why they are used in different cases, especially in part with free forms and complex features. A particular part inspected in geometrical tolerances is presented in Figure 1.

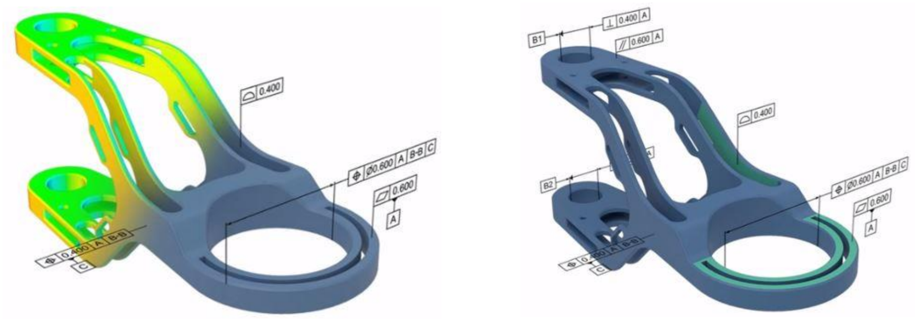

Fig. 1. Inspected part for geometrical tolerances check [19].

3.2 Displacements

In some cases, there are some special requirements related to dynamic measurements of 3D vibration displacement at individual points. This can be shown by the application of 3D digital measurement in the door of the car (Figure 2).

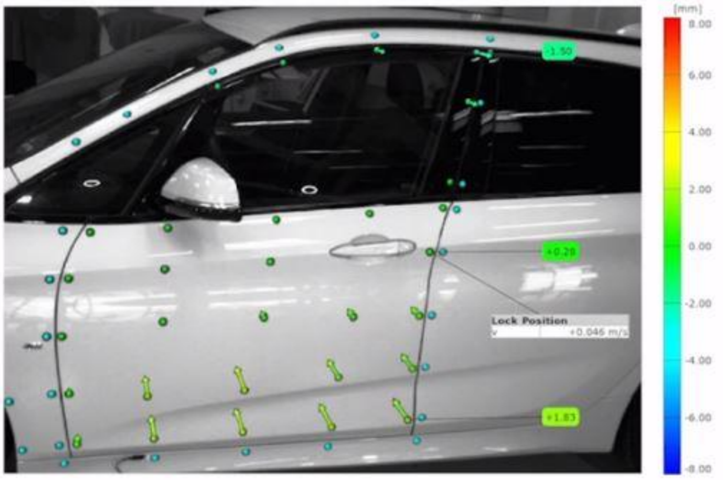

Fig. 2. 3D measuring the door of the car [19].

3.3 Deformations

Another aspect that is very important in terms of measurement is the deformation of the parts. This sends us on different mechanical testing and experiments on deformation. The 3D analysis of deformation of the part (Figure 3) and testing a 3D printed suitcase handle button (Figure 4) are presented below.

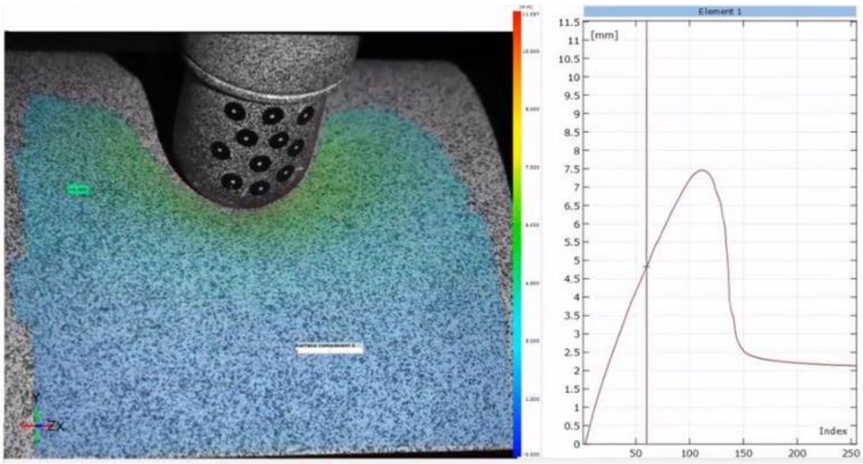

Fig. 3. 3D analysis of deformation of the part [19].

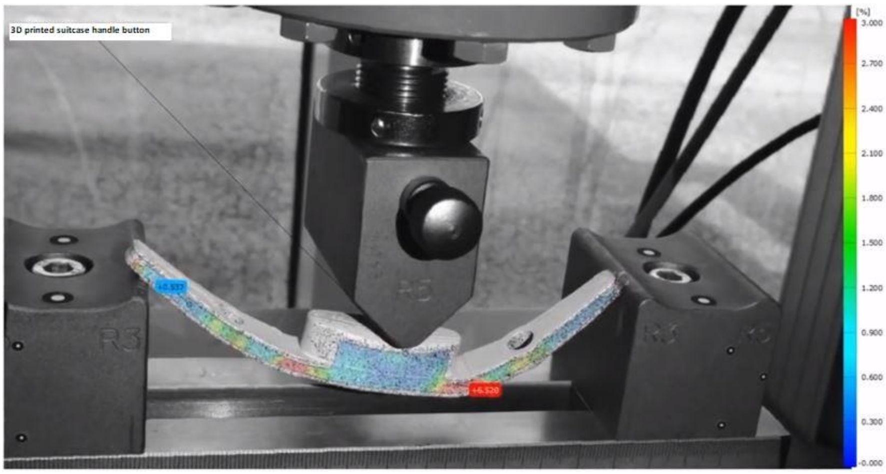

Fig. 4. Testing a 3D printed suitcase handle button [19].

4 Conclusions

In this paper, we tried to show some aspects of new technologies in 3D digital measurement. The literature review was presented in terms of scientific investigation of several important factors that are needed to be known when we use the 3D scanning technique. The practical applications using case studies were presented to show the real application [19]. Based on the presented research we can conclude:

- There is a constant increase of using non-contact optical methodologies for inspection of different parts.
- The importance of several factors during 3D digital measurement are crucial for achieving the accuracy on entire process.
- From case studies we can notice that there is high range of flexibility in 3D scanner devices to deal with different complex shapes of the parts. This was shown during measuring on dimensions, displacements, and deformations of the parts.

From a general point of view, we conclude that the use of 3D digital measurement technology is a useful methodology in different applications.

Further work should deal with improvements that are required in terms of the integrated measurement approach, including advanced manufacturing processes.

References

1. Shabani, B. and V. Dukovski, *Cloud oriented Additive Technology use for Fast Prototype Development*, in *UBT International Conference*. 2018b.
2. Shabani, B. and V. Dukovski, *REVERSE ENGINEERING AND ADDITIVE TECHNOLOGIES IN CIRCULAR ECONOMY.* Mechanical Engineering Scientific Journal, 2018a. **36**(2): p. 123-129.
3. Shabani, B. and Z. Pandilov, *ANALYZING AND APPLICATION OF REVERSE ENGINEERING FOR DESIGN AND DEVELOPMENT OF MECHANICAL PARTS.* Mechanical Engineering – Scientific Journal, 2017. **35**(2): p. 89-96.
4. Shabani, B., G. Vrtanoski, and V. Dukovski, *Integrated reverse engineering and additive technology systems.* Mechanical Engineering – Scientific Journal, 2018. **36**(1): p. 47-54.
5. Wieczorowski, M., M. Ruciński, and R. Koteras, *Application of optical scanning for measurements of castings and cores.* Archives of Foundry Engineering, 2010. **10**: p. 265-268.
6. Brajlih, T., et al., *Possibilities of using three-dimensional optical scanning in complex geometrical inspection.* Strojniški vestnik-Journal of Mechanical Engineering, 2011. **57**(11): p. 826-833.
7. Gerbino, S., et al., *On the influence of scanning factors on the laser scanner-based 3D inspection process.* The International Journal of Advanced Manufacturing Technology, 2016. **84**(9): p. 1787-1799.
8. Mendřický, R. *Impact of applied anti-reflective material on accuracy of optical 3D digitisation*. in *Materials science forum*. 2018. Trans Tech Publ.
9. Pereira, J.R.M., I. de Lima e Silva Penz, and F.P. da Silva, *Effects of different coating materials on three-dimensional optical scanning accuracy.* Advances in Mechanical Engineering, 2019. **11**(4).
10. Koteras, R., et al., *Measurement strategy as a determinant of the measurement uncertainty of an optical scanner.* Archives of Mechanical Technology and Materials, 2019. **39**(1): p. 26-31.
11. Cuesta, E., et al., *Metrological evaluation of laser scanner integrated with measuring arm using optical feature-based gauge.* Optics and Lasers in Engineering, 2019. **121**: p. 120-132.
12. Guidi, G., et al., *Laser Scanner-Based 3D Digitization for the Reflective Shape Measurement of a Parabolic Trough Collector.* 2020. **13**(21): p. 5607.
13. Eastwood, J., et al. *Smart photogrammetry for three-dimensional shape measurement*. in *Optics and Photonics for Advanced Dimensional Metrology*. 2020. International Society for Optics and Photonics.
14. Guerra, M.G., et al., *Use of Miniature Step Gauges to Assess the Performance of 3D Optical Scanners and to Evaluate the Accuracy of a Novel Additive Manufacture Process.* Sensors (Basel), 2020. **20**(3).
15. Sedlak, J., et al., *Analysis of the Wear on Machined Groove Profiles Using Reverse Engineering Technology.* 2021. **21**(4): p. 529-538.
16. Leach, R., et al., *Geometrical metrology for metal additive manufacturing.* 2019. **68**(2): p. 677-700.
17. Calignano, F., et al., *Accuracy of down-facing surfaces in complex internal channels produced by laser powder bed fusion (L-PBF).* 2020. **88**: p. 423-426.
18. Catalucci, S., et al., *Measurement of complex freeform additively manufactured parts by structured light and photogrammetry.* 2020. **164**: p. 108081.
19. 3D grupa klaster 3D tehnologija, 3D Seminar Module 1: *Measurement of shapes dimensions, displacements and deformations*. 2021. Webinar.

Design of Smart Device for Knee Joint

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Abstract. The relationship between people and technology is growing every day, technology assistance in transportation, technological equipment in surgery, miniature models that are informing the person about their health. Using these devices often happens to be complicated especially when it comes to older ages. The purpose of this paper is to develop a prototype that will measure the load directly from the person's knee. The device will contain several sensors that will sent to the ESP32 microcontroller, the person is informed on his mobile and it is very user-friendly. The device is built on the analysis of modeling by engineering software and has been implemented in practice, it is now capable of being used in various fields such as various sports, orthopedics, in the fields of prosthetics, etc.

Keywords: IoT, Cost oriented, Health Care, ESP32.

4 Introduction

Research into prostheses to meet human needs has also pushed technological development because over the last decade there has been considerable interest from academia as well as industry in creating advanced technological solutions to improve human mobility for the lower limbs, for example for the knee [3]. The main causes of lower limb problems are divascular diseases with a statistic of 80% and as another cause is also trauma, while other smaller causes include congenital deformities, cancer, wars (especially because of landmines that mainly affect civilians after military conflicts are over) [3].

The latest technological advances have begun the implementation of chips, which make it capable of standing and mobility in accordance with the wishes of the user or person. According to the vision of prosthetics, prostheses with implemented intelligence will be able to react according to the needs of people who will enable people with disabilities to perform almost natural activities, such as walking, running, descending and climbing stairs, cycling and even for swimming and diving [12].

5 Problem Statement

The aim is to design a simple elastic device which will also contain simple and inexpensive electronic components that will be able to inform the user of his knee about the circumstances that will occur.

A device will be designed which will be able to be used by people who have problems with the knees, the device will be easy to wear and also easy to remove from the body or from his knee. The device will be identified as a 'smart' device because in its structure will be placed electronic components that can control the condition of the person, depending on whether the person is on the move in the sense that he is able to walk or run, the device will enable its monitoring at all times and as a result the device is more efficient in energy consumption.

In some cases, monitoring devices have a cost that is sometimes impossible for people to afford, the system is designed to be affordable and above all read values directly from sensors which are located in the structure of the elastic prosthesis.

Another useful feature is the results of the activities of the persons are obtained which are transferred to the mobile application of the persons who are using the device, the device that enables this function is the ESP32 microcontroller, where on its board is integrated the Wi-Fi module and Bluetooth, which allows through these modules to inform the person about the condition of his knee. The application that enables the receipt of this information is also easy to use and enables in real time to see the state of the knee load during walking, running or even other activities.

6 Literature review

Smart devices or 'smart prostheses' are those types of prostheses that contain electrically impacted electronic devices, in the most appropriate sense it means if the person is at rest, the prosthesis will be passive which made us we understand that the device is not working. Whereas if the person starts to have activity, the prosthesis will start its functioning, will start collecting data from the sensors and according to the algorithm will produce results that will inform the person about the load on his knee. The prosthesis will not be able to restore the movements of the person with limb problems but will be able to analyze the movements and loads of the knee during sitting, lifting, walking, running and how while engaging in any sports activities [12].
The latest technological advances have begun the implementation of chips, which make it capable of standing and mobility in accordance with the wishes of the user or person. According to the vision of prosthetics, prostheses with implemented intelligence will be able to react according to the need of persons who will enable persons with disabilities to perform almost natural activities, such as walking, running, descending and climbing stairs, cycling and even for swimming and diving. [12].

3.1. State of the Art

The paper ‘Active above-knee prosthesis’[12] presents the problems they will solve, the methods they have used to solve those problems with the mechanical part as well as the application of electronic devices in their built prosthesis. Initially, a person was analyzed while walking, climbing stairs and descending, by some high-cost sensors, while as a control device was used the computer and software that enabled the reading of their values. Through the calculations are found the center of gravity as well as the displacement of the mass of the person while getting up from the chair, walking on horizontal paths, on sloping roads and on stairs. From the results obtained prosthesis model in CAD software, also in the software is applied an engine

to analyze the support that would make to the person while moving. The end result was a motor-less prosthesis designed to be used by people without lower limbs. Unlike the works mentioned above that have designed prostheses to enable the replacement of limbs of persons and only by providing physical prosthesis and not receiving constant information from the person who uses it. [12]
In the paper 'Dynamics of Human Gait (2nd edition)' [20] is presented the part of measurements by sensors that are located in the body of a person where the sensor data are presented on the computer as well. Measurements are made by high-cost sensors and are placed on the person's clothing during movement, the analysis of activities is done by both limbs, also not neglecting the center of gravity in the knees. Also, by monitoring the shifting of the weight during the movement from one knee to the other as well as to the two knees where the presentation of the values for the loads on the limbs are presented in graphical forms. The result in this paper was the analysis through sensors without producing any physical model that would facilitate the movement of persons during movement. In addition to the above work that presents the methods for obtaining data and presenting that data through the computer, in this paper we will receive continuous data and that data will appear on the person's mobile. [20]

4 Results

The device is already placed on the person's knee as it show Figure 1 and once programmed we will start reading data from the sensors, but the first data will be taken from the weight sensor FSR01CE, the values read by ESP32 for this sensor is shown in Figure 2.

The model that will be used in this test is a sensor for measuring weight. In our case we used an Ohm FSR sensor model. The Ohm FSR sensor exhibits unique dynamic resistance characteristics in relation to the number of forces or weights applied. The function or mode of operation of the sensor, generally the more force or weight is exerted on the surface of the sensor, the higher the resistance.

Figure 15: Implementation of sensors and Esp32 in the knees.

The MPU6050 is a Micro Electro-Mechanical System (MEMS) which consists of a 3-axis accelerometer and a 3-axis gyroscope inside it, as shown in Figure 2. It helps us to measure acceleration, velocity, orientation, displacement, angle changes and many other parameters related to the movement of the system or object.

```
|| Accm = -467 || GyroM = 0 || Senz = 97
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|| Accm = -457 || GyroM = 0 || Senz = 97
|| Accm = -469 || GyroM = 0 || Senz = 97
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Figure 16: Reading data from sensors

Figure 2 shows the results of the two sensors, read by ESP32. The two sensors were connected, through I2C communication and separate sensor ports with the control device and we obtained these values. If we analyze that the MPU6050 sensor, which gives two signals like accelerometer and gyroscope with certain values according to the condition and position of the person while the FSR01CE sensor also gives such values. If we analyze Figure 1, we notice that the person is in a standing position because the accelerometer sensor gives values (-466) and also the weight sensor gives 97% of the load, i.e., that the person is standing, on both feet the same and weighing on both feet the same, there is no movement because the values on the gyroscope are 0, in this case it would be to the detriment of the person for reasons because it is over the knee load his.

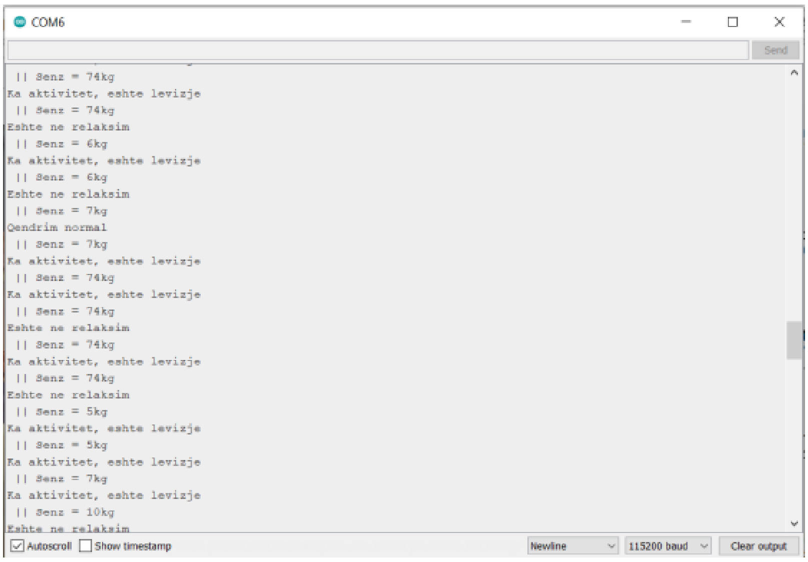

Figure 17: Creating labels according to data

Figure 3 shows a constant change in the state of human activity, as a result of which the movement of the person is found, from step to step constantly presented new values and a verbal comment to be understood by the person. When the patient moves on a flat surface or his condition is calm, the control part of the data collection shows us terms such as: ‘There is activity, it is movement’, ‘Normal posture’, ‘It is in relaxation’, etc.

- “Ka aktivitet, është lëvizje”, when the person is moving, in the sense of the activity of a sport or at least walking.
- “Është në relaksim”, as its result is that the person stays lying down and without load on the knee, that his condition may be sleep.
- “Qëndrim normal”, means that the person loads both knees with his normal weight, stands on his feet and no other position and also has no activity.

All these results are analyzed and different values of the sensor with measuring and changing the angle as well as by the sensor for measuring the weight. From these results we can conclude for patient's condition.
From different algorithms it is possible to check the condition of the person for problems from walking or load control on his knee, to inform the patient will be done by the application to be downloaded, the necessary application on the mobile, which can be downloaded free from stores offered by the application manufacturer and is called 'Blynk' is a new application that provides the ability to transmit information, which information can be in integer, string or decimal variables, etc. It receives this information from the control device in our case is ESP32 through this new application provides the ability to transfer values that are read directly from the sensors and transmitted to the patient's mobile. Broadcasting can take two forms, such as Wi-Fi and Bluetooth.

Figure 18: Display of data on mobile, such as "No load on limbs"

Figure 4 shows the patient's state when at rest, these triangular signals represent the weight load being carried over the knee or more precisely the patient's weight over the weight sensor, in which the results are obtained directly. In the load graph there have also been signals for load, now it is implied that the patient may have had movement and so far, remains in a state of calm without causing load on his knee.

Figure 19: Display of data on mobile, such as "It is on foot but not moving"

In this position the patient is standing upright or standing upright. In the graph module is presented the knee load, the signals presented as triangular shapes and not as constant signals, stands because of the delays in the transmission of information through the waves of Wi-Fi. If the patient would stay for a long time in normal posture as well as in the graph, we would see these types of signals. The history of his condition can be seen in the graph by pressing from the format ‘6h or

1w etc.'

Figure 20: Display of data on mobile, such as "It's moving"

According to this Figure 6, the shape of the patient's movement is presented. When the patient is walking, running or cycling we would get these types of signals in triangular and frequent shapes as well, this is because there is rapid activity for the patient if he is in good health but if the patient is not in such good condition, also produces results that are useful both for his personal needs and also for the health personnel who are responsible for controlling the patient's condition.

5 Conclusion

Initially, we can conclude that the overall implementation of the project was successful. The system implemented in practice turned out to be functional taking into account the problems electronic components, testing the device physically, transferring data to mobile. As we know we have three problems that we intend to address in this paper. Of course, the purpose in this application was to build a smart device that enables the analysis of his condition by the form of loading his knee, but with today's technological developments enabled us to make this device possible to be functional for people who are necessary for the use of this device and those who are interested in its operation.

The device is not able to return all the movement of the person but informs him about the load of his knee and that information will be able to be displayed on his mobile through the Blynk app. The device can be upgraded with the most advanced and modern sensors, which are permissible to be used in medicine, which made us get results with higher reliability.

References

[1] "ESP32," Components 101, 19 October 2018. [Online]. Available: https://components101.com/microcontrollers/esp32-devkitc.

[2] "FSRSensor," FSR, 2021. [Online]. Available: https://www.fsrtek.com/standard-sensor/f01-force-sensing-resistor.

[3] "Knee pain," Health Engine, 21 February 2006. [Online]. Available: https://healthengine.com.au/info/knee-pain#:~:text=It%20is%20estimated%20that%20the,incidence%20increases%20steadily%20with%20age..

[4] "Software Design PTC Creo," PTC, 2021. [Online]. Available: https://www.ptc.com/en/products/creo/.

[5] "Terapia për gjunjët," Klinika Balance, 8 Jan 2018. [Online]. Available: https://klinikabalance.com/terapia-per-gjunjet/.

[6] "What Is the Internet of Things (IoT)," Oracle, June 2019. [Online]. Available: https://www.oracle.com/internet-of-things/.

[7] R. L. Barrack, P. J. Lund and H. B. Skinner, "Knee Joint Proprioception Revisited," *Human Kinetics Journals,* vol. 3, no. 1, pp. 18-42, 1994.

[8] E. Bender, "The History Of Prosthetics," UNYQ, 21 9 2015. [Online]. Available: https://unyq.com/the-history-of-prosthetics/#:~:text=The%20most%20famous%20Ancient%20Roman,his%20shield%20and%20continue%20fighting.. [Accessed 6 6 2021].

[9] L. Bernstein, "What is Computer-Aided Design (CAD) and Why It's Imporatant," Procore - Jobsite, 11 October 2020. [Online]. Available: https://www.procore.com/jobsite/what-is-computer-aided-design-cad-and-why-its-important/.

[10] R. M. v. Bockel, T. Schoppen and K. Posterma, "Control of lateral balance in walking: Experimental findings in normal subjects and above-knee amputes," *Gait & Posture,* vol. 25, no. 2, pp. 250-258, February 2007.

[11] N. Hogan, "Impedance Control: An Approach to Manipulation: Part I - Theory," *Journal of Dynamic Systems, Measurement, and Control,* vol. 107, pp. 1-7, March 1985.

[12] Z. Jelacic, R. Dedic and H. Dindo, Active Above-Knee Prosthesis: A Guide to a Smart Prosthetic Leg, Elsevier Science, 2020.

[13] A. K.Silvermana and R. R.Neptune, "Muscle and prosthesis contributions to amputee walking mechanics: A modeling study," *Journal of Biomechanics,* vol. 45, no. 13, pp. 2271-2278, August 2012.

[14] L. Kark, D. Vickers, A. Mclntosh and A. Simmons, "Use of gait summary measures with lower limb amputees," *Gait & Posture,* vol. 35, no. 2, pp. 238-243, February 2012.

[15] P. Kristin M.LefebvrePT and P. StephenMetraux, "Disparities in Level of Amputation Among Minorities: Implications for Improved Preventative Care," *Journal of the National Medical Association,* vol. 101, no. 7, pp. 649-655, July 2009.

[16] S. M. Lephart, D. M. Pincivero, J. L. Giraido and F. H. Fu, "The Role of Proprioception in the Management and Rehabilitation of Athletic Injuries," *The American Journal of Sports Medicine,* vol. 25, no. 1, pp. 130-137, 1997.

[17] D. L. Logan, A first course in the finite element method, Cengage Learning, 2016.

[18] K. Z.-G. PhD, E. J. M. PhD, P. L. MPH, T. G. T. PhD and R. B. PhD, "Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050," *Archives of Physical Medicine and Rehabilitation,* vol. 89, no. 3, pp. 422-429, March 2008.

[19] A. K. Somani, R. S. Shekhawat, A. Mundra, S. Srivastava and V. K. Verma, "Smart Systems and IoT: Immovations in Computing," in *Smart Innovation, Systems and Technologies*, Singapore, Spring Nature Singapore Pte Ltd. 2020, 2019, p. 850.

[20] C. Vaughan, B. Davis and J. O'Connor, Dynamics of Human Gait (2nd edition), Howard Place, Western Cape 7450: Kiboho Publishers, 1992.

[21] A. H. Vrieling, H. G. v. Keeken, T. Schoppen, A. L. Hof, B. Otten, J. P. Halbertsma and K. Postema, "Gait adjustments in obstacle crossing, gait initiation and gait termination after a recent lower limb amputation," *Clinical Rehabilition*, vol. 23, no. 7, pp. 659-671, 26 May 2009.

[22] "MPU6050Sensor," Components 101, 17 March 2018. [Online]. Available: https://components101.com/sensors/mpu6050-module.

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