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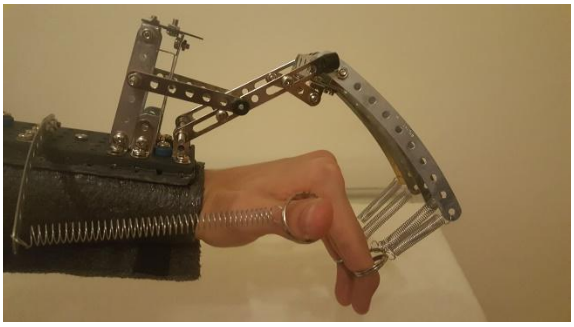

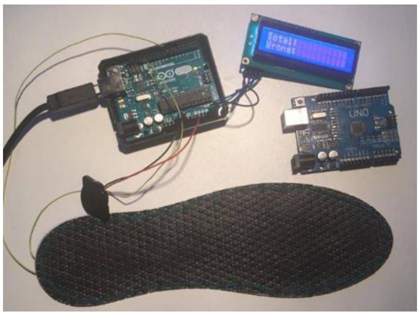

Images of the papers of the young researcher members of the Proca Center to the INGIMED 2016

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Our staff will contact the Guest Editors in order to arrange future actions concerning manuscripts.

Bulletin of Micro and Nanoelectrotechnologies includes the specific research studies on:

- Microelectromechanical and nanoelectromechanical components;
- The typical micro and nanostructure of actuators, micromotors and sensors;
- The harvesting microsystems;
- The conventional and unconventional technologies on MEMS and NEMS;
- The theoretical and experimental studies on electric, magnetic or electromagnetic field with applications on micro and nano actuating and sensing effects;
- The design algorithms or procedures of MEMS and NEMS components;
- The applications of MEMS and NEMS in biology and in biomedical field;
- The new materials in MEMS and NEMS;
- The standardization and reliability preoccupations;
- The economic and financial analysis and evolutions of MEMS and NEMS specific markets.

CHRONICLE

We dedicate the 1-2/2017 number of this Bulletin to the INGIMED 2017.

The papers represent the research scientific preoccupations of a new series of the members of Excellency Centre "Alexandru Proca".

Also, we present different images of the research projects ISEF 2017 competition (Los Angeles, USA, May 14-20, 2017) where the team: Ana Maria Tudorache and Miruna Ojoga win the medals for the project Microsensors Monitoring Devices Regarding the Rehabilitation Process Carried Out After Orthopedic Surgeries of the Lower Limb.

Editor in Chief

Mircea Ignat

"Alexandru Proca" Excellency Centre for the Youngsters Initiation in Scientific Research – The participation to the ISEF 2017 competition on the research projects

An image of the competition hall

An image of the finalist teams parade. Romania was represented by the Carmen Popa and Andra Ciutac (to the screen)

Grant Awards Ceremony, 4th place the medals for the team Ana Maria Tudorache and Miruna Ojoga

INGIMED 2016

The open speech of INGIMED XVII

An image of the discussion

Prof. Radu Negoescu presents the paper

Another image of the discussion of the INGIMED XVII

Contents

Nanotechnology for Bioenergy and Biofuel Production, (eds Rai M., da Silva S. S), Springer International Publishing, 2017, ISBN-978-3-319-45458-0, 65 b/w illustrations, 25 illustrations in color, p 370.

This book contains 15 chapters which covers many important topics related to the interplay between nanotechnology and biofuel production, including bioenergy transformations. After an introductory chapter dealing with Nanotechnological Solutions for Sustainable Production of biofuels, several chapters focus on the significance of nanotechnology for improved treatment of cellulose (Nanotechnology Applications on Lignocellulosic Biomass Pretreatment; Hierarchy Nano-and Ultrastructure of Lignocellulose and Its Impact on the Bioconversion of Cellulose; Role of Nanoparticles in Enzymatic Hydrolysis of Lignocellulose in Ethanol; Catalytic Conversion on Lignocellulose to Biodiesel Product), with emphasis on already obtained results as well as on perspectives for an economically efficient breakdown of recalcitrant substrates. The chapter “Multifunctional Nanoparticle Applications to Microalgal Biorefinery” presents, *inter alia*, the use of different type of nanoparticles to improve essential steps in microalgal refinery such as: harvesting, cell lysis or permeabilization (by the generation of reactive oxygen species, for example) , extraction of useful products as well as the conversion of raw materials (e.g. lipids) to desired product (e.g. biodiesel). Furthermore, (multi) functionalized nanoparticles, according to the authors, have great potential to significantly improve nowadays microalgal biorefinery to an economically efficient activity. Very interesting and promising results concerning bioelectrochemical properties of different types of carbon based nanomaterials are presented with respect to improve the conversion of chemical energy in electrical energy, using biofuels cells. Other important chapters deal with the applications of Nanotechnology (heterogeneous catalysts, Metal Oxide Nanocatalysts etc.,) in thermochemical conversion of microalgal biomass, conversion of biomass to fuels and bioenergy. The impact of nanocomponents addition to biodiesel used in diesel engines is also presented, which further argue the importance of nanotechnology in our current lives. The last chapter “Nanotechnologies and the Risk Management of Biofuel Production” strongly argue the true progress achieved in the use of nanotechnology for biofuel production, progress which should pay attention on the possible side effects of nanotechnology, toxicity for example. The book is written by reputed scientists in the field, the text is clear, and illustrations and references very useful (however, as a material prove that *il diavolo* works, at page 7 one can find the incorrect formulation “methanogenic bacteria”, instead of “methanogenic Archaea”…). In my opinion, this book must be available to students, researches and managers interested and working in the field of Bioenergy and Nanotechnology.

Ioan I. Ardelean

Microalgae Biotechnology, (Posten C and Pheng Chen S. eds), Springer International Publishing, 2016, ISBN 978-3-319-23807-4, 188p.

Microalgae Biotechnology is volume 153 of the Series Advances in Biochemical Engineering/Biotechnology. The book has an excellent introduction (Status challenges and goals) to the general topic of this volume. The chapter „Biology and Industrial Applications of Chlorella: Advances and Prospects" presents useful information about morphology, ultrastructure, growth and physiology which is further developed in the subchapter concerning its cultivation under different conditions: photoautotrophy, mixotrophy and heterotrophy. Potential applications (human food and animal feed; source of carotenoids; CO_2 biomitigation and waste water bioremediation; feedstock for biofuels; recombinant proteins) are also very well presented. The chapter "Microalgae as a Source of Lutein: Chemistry, Biosynthesis, and Carotenogenesis" is focused on this topic with emphasis on the cultivation of algae and the biochemistry of lutein synthesis, as well as on the regulation including the stimulation of carotenogenesis by oxidative stress. A strong and very attractive chapter is that dealing with the Modelling of Microalgae Culture Systems with Applications to Control and Optimization concerns the use of mathematical modeling taking into account the intrinsic biological properties, including cell biomass accumulation under different type of growth, and physical properties of the growing media (the distribution of light, cells trajectories, temperature variations). The chapter "Monitoring of Microalgal Processes" clearly presents the main physical and chemical parameters (light intensity, temperature, *p*H, carbon dioxide and molecular oxygen concentrations in liquid and in gaseous phase, the concentration of inorganic nutrients) of algal cultures (biomass concentration, cell density and purity, photosynthetic efficiency etc.,) which should be measured. Classical instruments to on- or off-line measuring these parameters are also presented, with special emphasis on novel measuring devices with great potential for industrial applications. Another chapter, "Photobioreactors in Life Support Systems" deals with results concerning the use of micro-algae as biocatalysts to generate molecular oxygen for human respiration in closed systems (space shuttles, for example), and to consume the carbon dioxide generated by human respiration. Special attention is devoted to stringent problems such as: the source (and characteristics) of light to support the algal growth, the appropriate design of bioreactors to be used in microgravity conditions. Practically each chapter of the book ends with very useful conclusions and future prospects which really help the reader to better fix in his/her mind the main content of each chapter, and to become in connection with the author's opinion about the future trends of each topic. The illustration of each chapter is very useful and the bibliography really rich. The index is, as usual, an useful tool for the reader. This book is an useful reading for scientists and entrepreneurs working in this field.

Ioan I. Ardelean

The Physiology of Microalgae (eds Borowitzka, M. A., Beardall J. and Raven J. A.), Springer International Publishing, 2016, ISBN-978-3-319-24943-8, 65 b/w illustrations, 166 illustrations in color, p. 681.

The Physiology of Microalgae, volume 6 of the series Developments in Applied Phycology, is edited by three titans of this domain. In the first chapter (The Cell Cycle of Microalgae) the authors present the main characteristics of classical binary fission cell cycle model, binary fission cell cycle model (as found in Scenedesmus) and binary fission cell cycle model (as found in Chlamydomonas) as well as the situation when the mother cell divides to multiple daughter cells (Cn). Special attention is devoted to the mechanisms of the regulation of cell cycles in algae, including molecular mechanisms involved in the influence of light and temperature and starch reserves. Chlorplast cycle is clearly presented in this first chapter and its relationship with cytosolic components, including nuclear DNA. In the second chapter (Biosynthesis of the Cell Walls of the Algae), even from the beginning the reader is pedagogically introduced to the extracellular coverings and their chemical composition in all algal groups, the microfilbrils and the matrix polysaccharides of green, brown and red algae. Photosynthesis is presented with emphasis on the following aspects: the photosynthetic pigments found in cyanobacteria and algae; algae with primary plastids and algae with secondary and tertiary plastids; light harvesting antenna in cyanobacteria and algae as well as the control of energy supply to Photosystem 1 and Photosystem 2 by state transitions; Different mechanisms for non-photochemical quenching; Reactive oxygen species and Carbon acquisition in microalgae with focus on RUBISCO, dark inorganic fixation as well as the use of organic carbon sources for growth. Molecular hydrogen production is copiously and deeply presented in this very interesting and useful book, with emphasis on direct and indirect biophotolysis by the well-known cyanobacterium Synechocystis PCC 6803, hydrogen production by filamentous, heterocyst forming cynaobacteria (Nostoc and Anabaena); cyanobacterial nitrogenases and different type of hydrogenases, together with their fine control of activity and attempts to change the flow of electrons and protons toward the maximalization of hydrogen production in different species. The chapter Dark Respiration and Organic Carbon Loss clearly presents different metabolic pathways of glucide breakdown (EMP, OPP, ED) linked with tricarboxilic (Krebs) cycle and respiratory electron transport, and proton pumping in/from mitochondria. Special chapters are devoted to mineral nutrition in microalgae: nitrogen, phosphorus, sulphur, micronutrirents (iron, selenium, silicon- and silicification) and calcium (and calcification). Chemically-mediated interactions in microalgae and molecular aspects of compatible solute accumulation are also presented in this book together with the biological signification of UV screening compounds, lipids, sterols, carotenoids, exocellular polysaccharides and genome. The interplay between algal physiology and large-scale outdoor cultures of microalgae is very concisely presented.
Each chapter contains very rich and useful information, including comprehensive illustrations and references. Each chapter is a chef d'oeuvre done by very well-known scientist(s) in their fields. The book, useful and needed both by PhD students and already experienced scientists, should be found/ accessible in every (significant) faculty, research institute or pilot plant dealing with microalgae!

Ioan I. Ardelean

Ethics of Biomedical Engineering versus Medical Ethics: Distinct Accents within a Common Paradigm

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Abstract - To begin, this paper is making distinction among moral, ethical and legal conduct, before approaching ethics in the medical paradigm and codes of ethics in biomedical engineering. Ethics of biomedical engineering and medical ethics feature a strong common trunk coming in essence from allying two professions based on a high labor educational process under the same scope of protecting/improving health and life – the core of medical paradigm. Distinct accents are coming from the treatment of the patient - in essence a medical responsibility, and from technological back-up of medical procedures – a responsibility of the biomedical engineer. Though infringement of ethical codes does not necessarily lead to law prosecution, losing the credibility and esteem from peers stand for a penalty more severe than possible legal claims.

Index Terms - bioengineering, biomedical engineering, clinical engineering, code of ethics, medical ethics, morals.

Motto: *"Technology and ethics are neighbors, not foreigners, facing rather than interfacing each other in the world of human accomplishment. Personal face of ethics looks at the impersonal face of technology to comprehend the latter's potential and limits directed at human purposes and benefits. "*Snehasish Mishra, 2011 [1]

I. INTRODUCTION

Morals is an assemble of rules featuring the worthwhile behavior of individuals and communities, infringement of which is not under sanction of law but rather under public opinion disapproval.

Ethics is related with, but a bit lesser than morals.

Being moral is meritorious (targeting the better for all), an ethical behavior is a correct one (versus the others), while the legal conduct is mandatory.

Morals, ethics and legality could be seen as spheres including each other, with morals as the largest, and legality as the core.

II. ETHICS IN THE MEDICAL PARADIGM

This According to Brey [2], components of medical ethics, are:

- beneficence, that is making patients to benefit in the sense of improving their health or even saving lives;
- non-maleficence, that is not doing harm (*primum non nocere*) at least, in trying to offer such benefits to patients;
- patient autonomy refering to the patient's right to choose among various proposed treatments or to refuse certain or all of those treatments;
- justice, meaning the equitable allocation of more or less scarce health resources, (including medications, medical devices attention and time of doctors & nurses);
- dignity, that is ruling out treatments placing pacients in undignified settings or postures;
- confidentiality, assuring that personal medical information remain inaccessible to the third part;
- informed consent, that is (often written) acceptance of the proposed treatment based on a proper understanding of the facts in terms of (dis)advantages or risks.

III. CODE OF ETHICS OF ENGINEERS

In accordance with the Accreditation Board for Engineering and Technology (cf. [3]), engineers uphold and advance the integrity, honor, and dignity of the engineering profession by:

- using their knowledge and skills for the enhancement of human welfare;
- being honest and impartial, and serving with fidelity the public, their employers, and their beneficiaries/clients;
- striving to increase the competence and prestige of the engineering profession;
- supporting the professional and technical societies of their disciplines.

IV. BIOENGINEERS VERSUS CLINICAL ENGINEERS IN TERMS OF ETHICS

Teaching Biomedical engineering (BME) is practised by bioingineers and clinical engineers.

Bioengineers are working in research laboratories to advance understanding of biology using engineering concepts. Ethical issues in bioengineering are those currently stated in bioethics and medical ethics that are towering the background of engineering ethics.

Clinical engineers are integrated in clinic and hospital practice and their specific ethics have often different accents from that of bioengineers.

Clinical engineers are similar to other engineers in that they are often involved in R & D of novel (medical) technologies, and differ from medical practitioners because they do not engage on their own in diagnosis and treatment of patients.

However they differ from other engineers, and are similar to medical practitioners, because they contribute to good patient healthcare, working sometimes hand-in-hand with physicians in high tech procedures. Subsequently, ethics of clinical engineers must combine both types of ethics.

Although clinical engineers are not medical practitioners, they can be truly seen as indirect or para-medical practitioners, since the techniques they develop/apply co-determine quality of medical practice [2].

V. BME-SPECIFIC ETHICS

In accordance with the Code of Ethics of the US BME Society (an organization with 7,000 USA members), what follows is specific to BME (vs nonspecific, i.e. belonging to the common healthcare paradigm) [4].

Biomedical engineers in the fulfillment of their professional duties shall:

- use their knowledge, skills, and abilities to enhance the safety, health, and welfare of the public (subjects and patients, our note);
- strive by action, example, and influence to increase the competence, prestige, and honor of the biomedical engineering profession.

Biomedical engineers involved in healthcare activities shall:

- regard responsibility toward and rights of patients, including those of confidentiality and privacy, as their primary concern;
- consider the larger consequences of their work in regard to cost, availability, and delivery of health care.

Biomedical engineers involved in research shall:

- comply fully with legal, ethical, institutional, governmental, and other applicable research guidelines, respecting the rights of colleagues, human and animal subjects, and of the scientific and general public;
- publish and/or present properly credited results of research accurately and clearly.

*

Somehow similarly, the Code of Ethics of the in the IEEE Engineering in Biology and Medicine (11,000 members worldwide) states that biomedical engineers should specifically [5]:

- respect human dignity and privacy of patients and human subjects;
- ensure proper safeguarding of all confidential information, including patients, subjects, commercial entities, and trade secrets;
- promote a culture of cost-effectiveness;
- support preservation of a healthy environment;
- engage in research aimed at advancing the contribution of science and technology to improving healthcare provision;
- report research results with scientific integrity and proper due credit;
- observe the rights of human research subjects and strive for a balance between benefits and potential harm;
- ensure a responsible and humane use of animals in research;
- conduct (contribute to, our note) clinical research studies in accordance with Good Laboratory Practices and Good Clinical Practices;
- hold in high regard the inter-disciplinary nature of healthcare delivery and research. Foster collegial inter-disciplinary relationships. […]. Encourage a culture of knowledge exchange and mentorship […].

VI. THE “COMMON TRUNK” OF MEDICAL AND BME ETHICS

Medical and BME ethics feature a significant „common trunk” as follows [3].

Professional ethics:

- being honest and impartial;
- not publishing false reports.

Patient ethics:

- confidentiality;
- full disclosure.

Natural & human ethics:

- not “playing God”;
- not interfering with natural life and/or nature;
- not crossing the line between improving quality of life and changing life.

VII. PECULIAR ETHICAL QUESTIONS INVOLVING BME

Brey [2] treats a few controversial ethical questions in the BME domain.

BME techniques may be used to enhance healthy human traits beyond a normal level, e. g. human enhancement in terms of strenght/intelligence via SCT or Germline, that may evetually lead to superhumans; that poses sometimes ethical problems.

Somatic cell therapy (SCT) means genetic modification of bodily cells other than sperm or egg cells in order to replace defective genes with functional ones. As a matter of evidence, somatic cell gene therapy to treat serious diseases is ethical.

With *germline engineering* (under study, yet) genes in eggs, sperm or very early embryos are modified; that is controversial since inheritable modifications of the genome pass on to future generations.

Tissue engineering aims to create artificially grown organs for patients that need organ transplants; ethical controversies arises for use of xenogenic (animal or vegetative) and human embryonic tissue (stem and germ cells); problem remains: how to balance the prolonging of life with the quality of life ?

Prostheses and implants may arise ethical questions upon human identity and dignity, because it involves the addition of artificial structures to human biology, or even the replacement of human tissues and organs with artificial versions.

Biomedical imaging has obvious benefits for science and healthcare. Concerns intervene when diagnostic imaging may lead to an excess of diagnoses; brain imaging can also today reveal information about a person's mental states or plans for action (mind reading) that cold be used for manipulation & control.

Neural engineering poses ethical questions on integrity and dignity of persons, as artificial neural devices may affect personal identity and make the human mind or brain partially artificial, turning humans into cyborgs. As for neuroenhancement, problem sounds: should neural engineering be used to develop artificial devices that allow humans to have superior perception, cognition or motor control, or positive moods and attitudes ?

VIII. BREAKING THE CODES OF ETHICS

Ethics means standards and infringers are not necessarily legally prosecuted. At stake there are mainly credibility and esteem from peers and & elite organizations.

However, the infringer may be sued, e.g. in the form of torts or personal injury law suits.

A case study on professional ethics infringement, the so-called "stem cell misconduct" (2005-2006) is discussed by Kennedy [3] in terms as follows:

"Dr. Hwang Woo-Suk, a researcher and professor (of veterinarian background, our note*) at Seoul National University published two papers in Science, claiming his team had succeeded in creating human embryonic stem cells through cloning.*

Allegations followed from a co-worker that these paper was based on fabricated data. An inquiry was conducted; as a result:

- *the papers were editorially retracted;*
- *Dr. Hwang lost his position at Seoul National University.*

The South Korean government ended its financial and legal support of his research".

IX. CONCLUSIONS

Ethics of biomedical engineering and medical ethics feature a strong common trunk coming in essence from allying 2 professions based on a high labor educational process under the same scope of protecting/improving health and life – the core of medical paradigm.

Distinct accents are coming from the treatment of the patient - in essence a medical responsibility, and from technological back-up of medical procedures – a responsibility of the biomedical engineer.

Professional specific ethics has nowadays a weight comparable with preclinical medical topics in biomedical engineering curricula.

Though infringement of ethical codes does not necessarily lead to law prosecution, losing the credibility and esteem from peers stand for a penalty more severe than possible legal claims.

X. REFERENCES

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[5] Code of Ethics of the Biomedical Engineering Society: ethics.iit.edu/ecodes/node/3243.

XI. BIOGRAPHY

Radu M. Negoescu got the MS degree in 1969 from the Bucharest Polytechnic Institute, then obtained the PhD in electronic engineering from the Institute of Nuclear Physics & Engineering in 1986, and the MPH degree in public health management from the University of Medicine and Pharmacy in 2001.

His employment records include the National Institute of Public Health in Bucharest - where he is currently honorary head of Health Promotion Unit, National Institutes of Health (Bethesda, MD), and Totts Gap Institute (Bangor, PA, USA).

His research includes cardiovascular bioengineering, bio-signal processing and neuro-cardiology. He is a honor member of the Academy of Medical Sciences and a senior member of the IEEE.

The Strap-on Spring System for Medical Rehabilitation of the Fingers

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***Abstract* -** This project's purpose is to develop a device for the medical rehabilitation of the fingers. The author presents different features and experiments and the technological aspects.

Index Terms - rehabilitation, strap-on spring structure, spring system, hand, fingers.

I. INTRODUCTION

Rehabilitation is a treatment or series of treatments designed to facilitate the process of recovery from injury, illness or diseases to condition as normal as possible.

Objective:

The objective of rehabilitation is to restore some or all of the patient's physical, sensory and mental capabilities that were lost due to injury, illness or disease. Rehabilitation includes assisting the patient to compensate for deficits that cannot be reversed medically. It is prescribed after many types of injury, illness or diseases including amputations, arthritis, cancer, cardiac diseases, neurological problems, orthopedic injuries, stroke, traumatic brain injuries or spinal cord injuries.

II. THE ANATOMYCAL AND PHYSIOLOGICAL DESCRIPTION OF THE HAND AND FINGER

Because our research project is concentrated on the hand's rehabilitation we present a short anatomical description of the hand. Based on our research of the hand structure, we have developed devices which will involve all of the muscles and bones of the hand.

In the recovery process we aim to improve the state of the following bones, which contribute to the movement of the finger: the carpal bones (a), the metacarpal bones (b) and the phalanges (c).

The skeleton of the hand is formed by 27 bones that can be placed in three groups:

Carpal bones: They are placed on two transverse rows, each one of these rows being formed by four bones.

Metacarpal bones: They are present in a number of five and form the skeleton of the palm. These are connected with the second row of carpal bones above and with the proximal phalanges below.

Phalanges: There are 14 in number, each finger having three of them except the thumb, which has only 2. They are grouped in proximal phalanx, distal phalanx and medial phalanx.

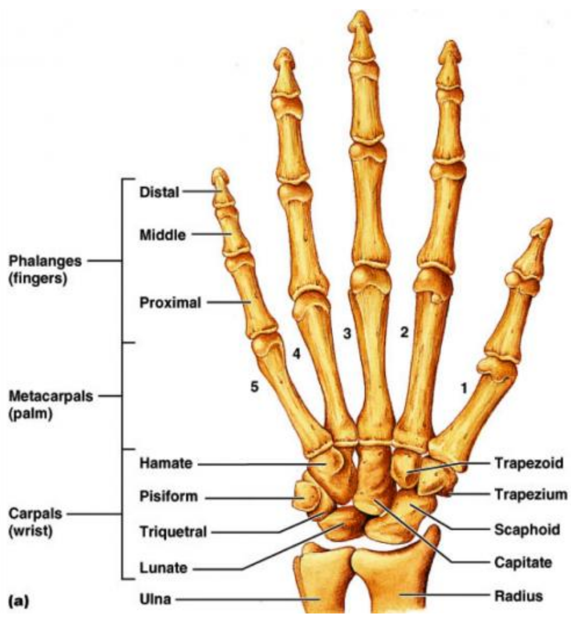

Fig. 1. The structure of the hand

The Muscles of the hand

Many muscles have a part in the mobility and flexibility of the hand.

Extrinsic muscles. Located in the forearm, they transmit the movements of the hand and fingers through long tendons that lead either to the palm (tendons of the flexor muscles) or to the back of your hand (extensor tendons of the muscles).

Intrinsic muscles. Located in the hand, they transmit precise movements of the fingers. Interosseous muscles are divided, depending on their position, in dorsal muscles (back of the hand) or palmar muscles (palm), and allow closing or furthering of the fingertips. Lumbrical muscles, present in each of the five fingers help flexion and extension.

The fingers

Fingers do not contain muscles, only ligaments and tendons which come from the muscles of the hand and forearm. The last four fingers contain two long tendons each, for flexion and extension respectively, coming from the forearm muscles. The thumb is controlled by the tendons of the extensor muscles and flexor muscles, and also by two main ligaments(inner side and outer side).

III. THE STRAP-ON SPRING SYSTEM

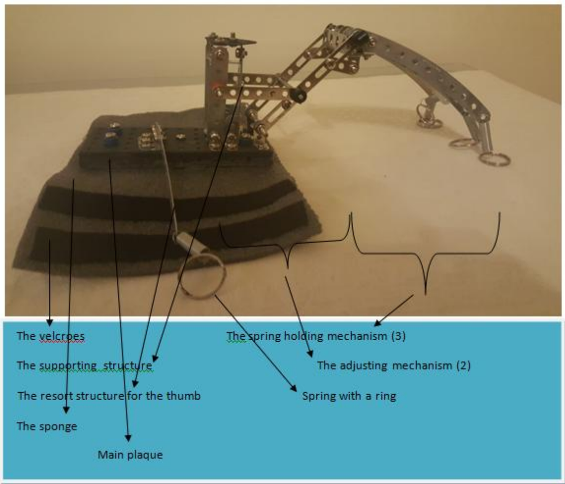

Fig. 2. The strap-on spring system

This device is the main piece of the project, designed to help the recovery of the fingers. It is a spring system that can be strapped on the hand and allows exercises consisting of pulling the springs from different angles. This way, all the muscles can be trained, helping the hand recover. Furthermore, the device is fully adjustable for the user and can be equipped and used without help.

Main benefits:

One of the main benefits of this structure is that it can be strapped on the hand for exercising while walking or doing other things. We consider that this is a very important quality for a rehabilitation device because, this way, it can fit into the person's daily routine and he does not need to stay still in only one place to exercise, like with some other devices. Also, the patient can exercise without holding his arm up, due to the fact that the device can be perfectly used while the hand rests in a normal position, this also applying to sitting in bed, on the couch or any other way.

Another important characteristic of this device is that it is extremely mobile, allowing the user to have access to multiple exercises and also to adjust the device to his liking. These things are all possible because of the structure of the device, which is comprised of three parts:

- **the strapping mechanism (1),** the part that is designed to be strapped on the hand;
- **the adjusting mechanism (2),** that allows the springs to be adjusted specifically for the patient's needs;
- **the spring holding mechanism (3),** that holds the springs, while also allowing the user to replace them based on his needs.

The strapping mechanism(1)

Fig. 3.The strapping mechanism (1)

The strapping mechanism is what connects the patient's body and the resort system. It is made of 3 inner layers of thin sponge, that are held inside the main plaque with screws and bars, that are glued to another larger layer that wraps around the hand and can bind together using Velcro's.

There are 2 Velcro's placed horizontally and 2 vertically, to ensure stability and choice of the strength of the grip. We also made sure that this device can be set up single - handedly, without someone else's help, a necessary trait when the patient is alone and wants to exercise.

The adjusting mechanism(2)

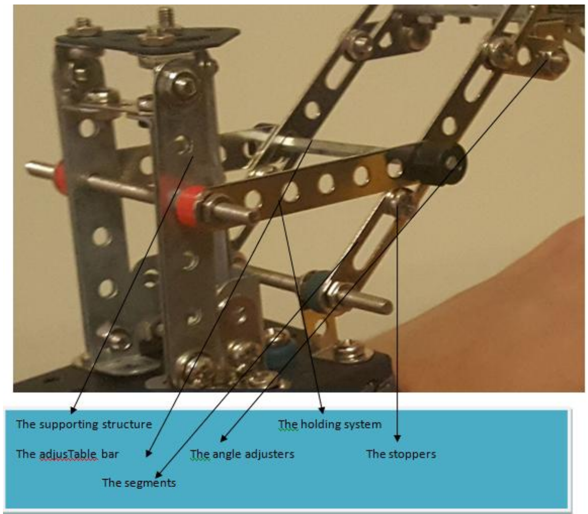

Fig. 4. The adjusting mechanism (2)

The role of this mechanism is to adjust the height and length of the spring's supports from the hand. In this way, the patient can set these parameters by himself in order to allow him to do a wide array of exercises. The way is works is that two segments that are connected to a bar at one end and the spring structure at the other can move freely to lower, raise, push forward or pull backwards the springs. The mobile system spring's is held in place by a removable bar that ties the segments with the supporting structure. Therefore, the bar can be removed and placed by the patient anywhere in the desired position placing the bar in holes available on the segments, this way allowing to adjust the above said parameters. There are also movable stoppers that can hold the adjustable bar, like shown in the picture. Also, the angle between the segments and the spring structure can be altered using the angle adjusters, further extending the possibilities of the device. We will now present some of the ways in which this system can be used:

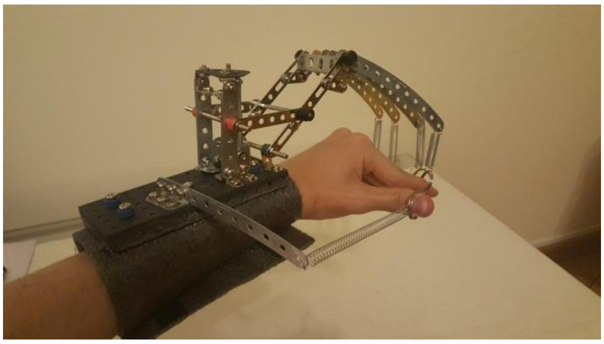

Fig. 5. The „small movements" vertical pulling method

This is the most basic method for pulling, involving only small vertical moves with the fingers, movements being made with low - medium force.

The movable bar is set above the stoppers, so that the springs are directly above the hand.

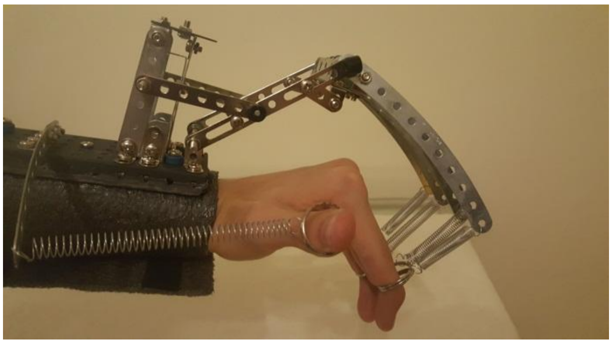

Fig. 6. The „big movements" pulling method

This method involves the same pulling method as the above example, but using full force instead low – medium force.

The movable bar is set in the same position as in the basic method.

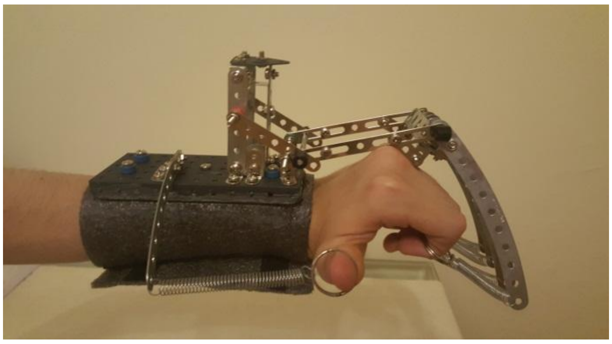

Fig. 7. The horizontal pulling method

In this method the patient pulls the resorthorizontally with the space between thephalanges, targeting different groups of muscles.

The adjustable bar is placed underthe stoppers, but it is held at the second holeof the bars that connect the sustainingstructure with the main bars, so that thespring bars are lower and in the front of thefingers.

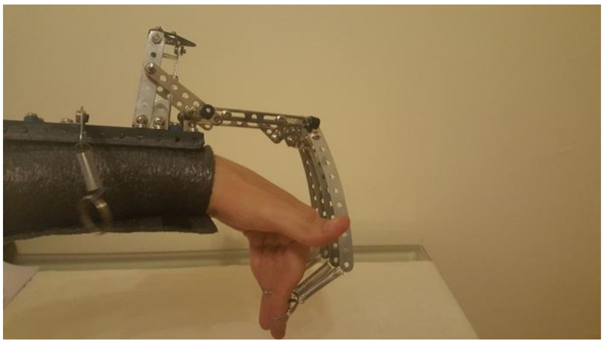

Fig. 8. The vertical fingers method

This method involves an horizontal pull bythe patient towards himself, with the fingersstarting from a vertical position as shown.

The adjustable bars are placed in the sameway as in the previous method.

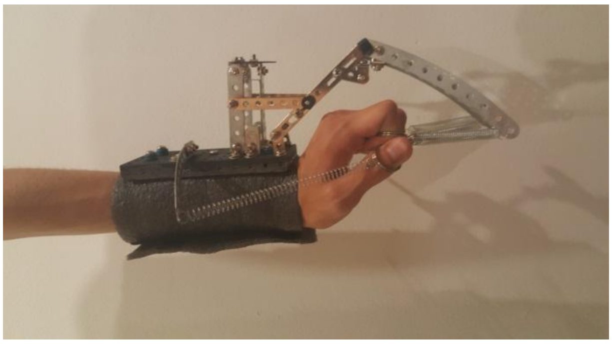

Fig. 9. The raised hand horizontal pulling method

In this method, the patient pulls the resorts horizontally, but raising his fingers as shownin the picture. The movable bar is set thesame as in the first two methods, above the stoppers.

The spring holding mechanism (3)

Fig. 10.The spring holding mechanism (3)

The spring holding mechanism is designed to allow sideways movement for the curved bars to fit the specific design of the patient’s hand, but does not permit the bars to move up or down, ensuring that the exercise is done in good conditions. This is accomplished by using a fixation bar that connects the curved bars together. The springs can vary, and we have 5 springs in our set to accommodate each patient’s needs.

IV.EXPERIMENTS

We have calculated through experiments the force versus displacement of all the models of springs. Below, in Tables 1, 2 and 3 we have gathered the data from our experiments.

Fig. 11.The 3 models of springs

Spring 1

Diameter of the resort=0.74 cm, Length=6.207 cm, Number of coils=84.

TABLE I.

L [mm]	F [gf]
61.28	**500**
44.79	**400**
28.52	**300**
21.35	**250**
9.98	**150**
6.50	**100**
0	**0**

Spring 2

Diameter of the resort=0.77 cm, Length=3.339 cm, Number of coils=43.

TABLE II.

L [mm]	F [gf]
0	**0**
5.92	**100**
8.81	**150**
15.49	**250**
19.34	**300**
28.69	**400**
39.42	**500**

Spring 3

Diameter of the resort=0.6 cm, Length=2.312 cm, Number of coils=38.

TABLE III.

L [mm]	F [gf]
0	**0**
7.37	**100**
15.93	**150**
34.05	**250**
42.98	**300**
62.61	**400**
84.11	**500**

V. CONCLUSIONS

The final goal of this project is to design and perfect a device for the medical rehabilitation of the fingers which can fit into the life of the user, allowing the recovery process to be as pleasant and efficient as it can be.

VI. ACKNOWLEDGEMENTS

I couldn’t have possibly made this project without the help and guidance of our coordinator Mircea Ignat and the moral support from my family. They all have been willing to help me whenever they could, from reviewing my project to testing the device and realizing that it really was functioning properly.

Thank you so much for supporting me !

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VII. BIOGRAPHY

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Diagnostic Methods of Neurological Diseases through the Analysis of Dynamic Parameters of the Locomotor System

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Abstract **-** This study targets the modification of the dynamic parameters during the evolution of certain neurological diseases. The parameters used are the acceleration, speed and position in space. The study suggests that using a device composed of a hardware component (a gyroscope-accelerometer system) and a software, which processes the data, we can detect early stages of Alzheimer, Parkinson and help in the recovery of the patients who suffered from multiple sclerosis, head injury and cerebellar stroke.

Index Terms - portable analysis system, gait parameters, multiple sclerosis.

I. INTRODUCTION

Human body can experience a range of modification at the level of the locomotor system such as a decrease in the motor activity (hypokinesia, bradykinesia) or an increase in the motor activity (hyperkinesia).

In multiple sclerosis (MS), a chronic progressive disease of the central nervous system (CNS) characterized by inflammation, demyelination and destruction of the motor and sensory axons within the brain and spinal cord, patients usually have early mobility impairment. Therefore, the need for suitable system that can detect subtle gait and balance impairments is indisputable. In order to study this aspect of MS, only MS patients with overt clinical disability were used but there is some evidence to suggest that, even for patients with minimal neurological signs on clinical examination, subtle gait and postural control changes may be detected with proper equipment. The first study conducted on two distinct groups of people recently diagnosed with MS who present with mild neurological signs was made in 2006 by C.L. Martin, B.A. Philips, H. Butzkueven, N. Tubridy, E. McDonald and M.P. Galea and their conclusions highlight the usefulness of measurements to detect gait abnormalities in early stages of MS. [1]

A well-known pattern of the cerebellar stroke is the ataxic gait which is described as clumsy, staggering movements with a wide-based gait. The cerebellum helps maintain the smoothness and precision of movements for the limps, trunk, eyes and the voice. Holmes G. has defined cerebellar ataxia as a combination of dysmetria, dyssynergia, dysdiadochokinesia, dysrhy-thmia, and intention tremor. The CD gait is characterized by increased foot rotation angles in combination with almost normal ranges on motion of the lower extremity, and relatively unchanged gait velocity and stride length, which decreases in severe stages of the disease. Therefore, the need explore for technological ways to track the gait parameters in clear. [2]

At the International Conference for Alzheimer held in Vancouver in 2012, five studies were presented in order to link gait abnormalities to Alzheimer. Dr. Wally Wagster, head of the behavioral department and research in the cognitive and emotional change, claimed that "Changes in walking may predate actually observable cognitive changes in people who are on their way to developing dementia". One of the studies involved more than 1,100 elderly people in Basel, Switzerland. "A lot of times normal walking looked normal, even in people with moderate Alzheimer's, but if you look at dual tasking, I can detect these problems," said Dr. Bridenbaugh. Her research consistently showed that people who walked more slowly or inconsistently did worse on cognitive tests; the worst walkers had the most severe Alzheimer's. Next, said Dr. Bridenbaugh, "what we need is to use the information we have here and find a screening tool that physical therapists and doctors can use to red flag those who have a mobility problem. This should be basic. When your patient is in your office and you listen to their heart, it should be basic to see how they walk." The connection between Alzheimer and gait changes is still studied but the development of our system can be useful. [5]

II. THE OBJECTIVE OF THE STUDY

What this study is proposing is the use of an alternative portable system in the diagnosis of Parkinson and Alzheimer and in the recovery from multiple sclerosis, head injury. The system and the software must be calibrated for this task.

III. THE HARDWARE COMPONENT

In order to record data regarding patients' gait, we used a Raspberry Pi 2 Linux machine and an accelerometer and gyroscope assembly – the integrated circuit is named MPU6050 [6]. This piece provides the data we process for calculating the rotation angles and the instantaneous accelerations of the body. Those parameters allow us to analyze the movement of certain points of interest (for instance, the center of gravity, the knees, the heels and so on) of the system's user.

IV. THE SOFTWARE COMPONENT

The implementation of the algorithm is done using the GCC compilers of Linux operating system and the used programming languages are C and C++.

The data provided by the accelerometer consist of instantaneous accelerations on three perpendicular axes. In order to analyze the displacement of the point of interest into the space we needed to find a method of transforming those into sets of accelerations independent of the objects rotation. We used the rotation angles of the device and the rotation matrices in order to process trihedral of accelerations. The rotation angles were calculated using the Kalman Filter (explained in the mathematical analysis section). Therefore, the two results are mediated: the rotation angles calculated using the rotation velocity and the ones calculated using trigonometric functions and the instantaneous acceleration.

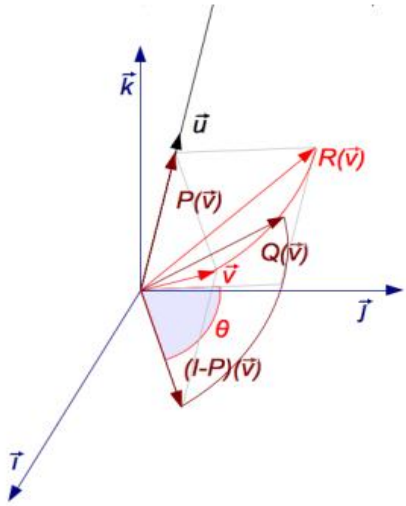

Fig. 1. The rotation angles of the body

The data is stored in files in order to be analyzed using programs which provide a graphical visualization.

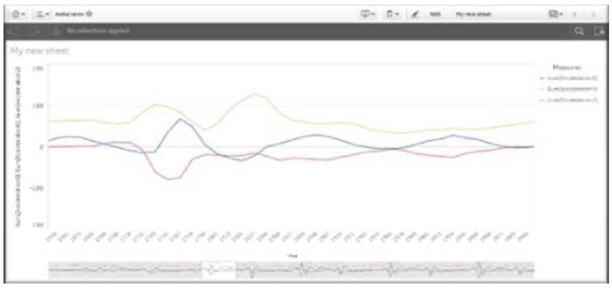

Fig. 2. Graphical visualization of data

V. DESCRIPTION OF THE EXPERIMENTAL RESEARCH

The first prototype is attached to the back of the patient so that the sensor will be close to the center of gravity.

Fig. 3. Prototype attachment to the patient

VI. THE MATHEMATICAL ANALYSIS

As previously mentioned, our device collects and displays the data in graphs (the values of the acceleration on 3 axes).

A. Calculating the speed and position in space

So be a function $S(t)$ that gives the position in space of a point in time. Through the derivation of the function $S(t)$ we get the rate with which the position in space changes in time or the speed. On the other hand, so be a function $v(t)$ that gives the speed of a point in time. Through the derivation of the function $v(t)$ we get the rate with which the speed changes in time or the acceleration. This shows a clear relation between the three parameters: acceleration, speed and position in space. The reverse process is the integration and this is the process that we used.

We integrate using a numerical method called The Trapeze Method:

$$\int_a^b F(x)dx \sim (b-a)\left[\frac{f(a)+f(b)}{2}\right] \quad (1)$$

B. Converting data

In order to be able to analyze the arbitrary points in the graph we need to convert them into a known function that mimics the data trends.

Lsqcurvefit is a Fitting Data function from the MatLab software that returns almost any type of function. We used it to return a polynomial function of 10^{th} degree.

$$x = lsqcurvefit(fun, x_0, xdata, ydata) \quad (2)$$

where:

i. *fun*- the type of the function,
ii. x_0- the start point.

Behind *lsqcurvefit* we find the Trust-Region-Reflective Least Squares algorithm which uses the approximation in Taylor Series (the first and the second derivative). This is a recursive algorithm which approximates the given data into a simpler function that reflects the behavior of the value *x* in a trust region N, that has a spherical or ellipsoidal form and is determined at every step using the first two derivatives.

C. Statistical parameters

i. Amplitude, which is the parameter that shows the distance between the minimum value and maximum value. We used it to delineate steps when analyzing the data from the graph.
ii. Standard deviation.
iii. The Trust Region, it was used to determine a trust region for walking and to see the tendencies in walking and to establish whether a person has too many "errors outside the given interval" or not.

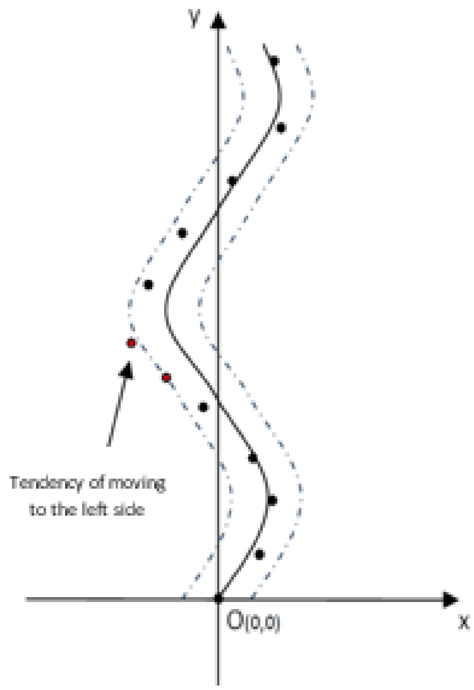

Fig. 4. The statistical parameters

D. The Kalman Filter

Kalman Filters are ideal for systems that are continuously changing such as ours. The basic idea of the Kalman Filter is a method of predicting the future state of a system based on the previous ones. Thus *x* depends on its previous value x_{t-1} plus some control input from the previous step, u_{t-1} and some noise w_{t-1} in a linear way: $x_t = Ax_{t-1} + Bu_{t-1} + W_{t-1}$.

Also, we have the measurement *z* which is a function of x plus some noise: $z_t = Hx_k + v_k$ (both the process noise and the measurement noise are assumed to be normally distributed). This tells us that any measurement is a linear combination of the signal value and the measurement noise. After succeeding to fit our model into Kalman Filter, then we determined the necessary parameters and our initial values using covariance matrices.

The Kalman Filter uses a prediction matrix given by a basic kinematic formula: $p_k = p_{k-1} + \Delta t v_{k-1}$. The prediction matrix used is $\begin{bmatrix} 1 & \Delta t \\ 0 & 1 \end{bmatrix}$. In order to link to states we use a covariance matrix, in which each element is the degree of correlation between the two states (P_t). In order to update the covariance matrix we analyze what happens when we multiply every point in a distribution by a given matrix.

In our study, when analyzing the human motor system, we have to take into consideration external forces. Hence, the Kalman Filter gets the expanded covariance by adding Q_k. Therefore, the new best estimate is a prediction made from previous best estimate plus a correction from external forces.[2]

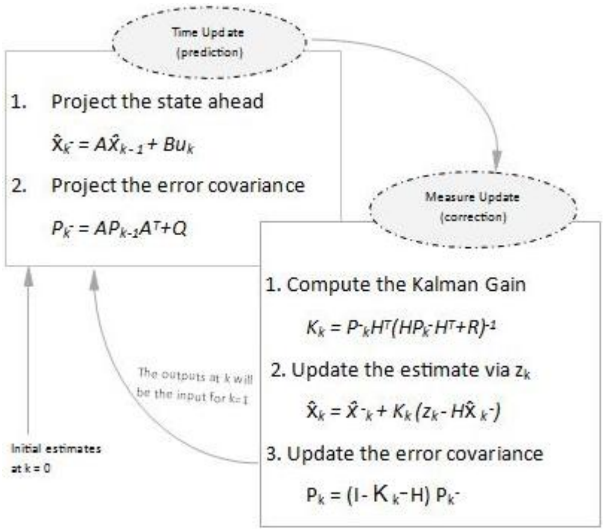

Fig. 5. The Kalman Filter application

VII. FUTURE PLANS

What we plan to do further with this project is to: make the system store data for each experiment carried out, which will be accessible in a Cloud database. This data will come along with pieces of information such as age and other details related to the patient's medical history. Our goal is to create an algorithm that will analyze different sets of data by comparison with already existing data – an algorithm capable of identifying gait traits that are common in patients with various common traits.

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VI. BIOGRAPHIES

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Study of the Elementary Surgical Procedures and Instruments with Applications in the Micromechanics of Surgery

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Abstract **-** This paper presents and analyzes the most important surgical procedures, all in order to develop several mechanisms able to teach and evaluate aspiring surgeons and even specialists within their subject of work. Final models of the prototypes are also included, where the performance of the surgeon can be interpreted from the pressure they apply to the tissue and the precision of their incision.

Index Terms - surgical procedure, tissue, surgical instruments, incision, prototype.

I. RESEARCH THESIS

The theme of this research project is creating different methods suitable to analyze one's accuracy. Starting from theoretical studies of medical instruments and procedures, as well as studies of biomechanics of the tissue, we introduce a number of devices that can be used to monitor precision and accuracy.

Domains of value of the micro drive:

- specific geometry and the structure of the micromechanics of surgery;
- angular displacement areas;
- linear displacement areas;
- micro forces of the drive;
- mechanical micro couples;
- micro forces.

Characteristics and mechanical parameters:

- Spherical diameters: 0-250 mm;
- Linear areas: 0-5 mm;
- Angular areas: 0-60;
- Meridian plans;
- Micro forces areas: 0-100 cN;
- Power: 0-100 W;
- Speed: 0-100 cm per second;
- Speed area: 0-30 rpm;
- Pressure: 0-200Pa.

II. INTRODUCTION

Over millenniums people have understood the importance of surgery and medical practice, developing it continuously. Even if through major scientific and medical break-outs, the mortality rates of patients undergoing an invasive treatment have steadily decreased, it is often the art of the doctor to operate safely (this meaning not only a sterile, disinfected surgical territory, but also the fine execution of each procedure). Therefore, we believe that by developing several mechanisms providing data regarding the manner a procedure is executed, surgeons can be more easily and accurately assessed in relation to the modern operating guidelines.

III. MAIN FUNCTIONS OF THE SURGICAL INSTRUMENTS

The functions of the basic surgical instruments vary, but can be classified within six categories, considering that an instrument might have several uses.

a) *Cutting and dissecting*: scalpels, scissors, dissector, ultrasonic cutting device, LASER, amputating knife, saws, raspatories;
b) *Grasping*: thump forceps, needle holders, organ clamps;
c) *Hemostasis (mechanically or thermally stop a bleeding)*: homeostatic forceps, Argon bean coagulator, Deschamp Ligation needle and Payr sonda;
d) *Retracting*: hand-held retractors, self-retraining retractors;
e) *Closing/Tissue unifying*: needles, staplers, self-adhesive strips, surgical adhesives;
f) *Special*: Volkmann curette, round-ended probe, suction set, X-RAY, implants, prosthesis etc.

IV. DESCRIPTION OF THE MEDICAL EQUIPMENTS AND PROCEDURES

The scalpel is one of the most frequently used cutting and dissecting surgical instruments. It can be either conventional (reusable), disposable (with a plastic handle) or with a detachable blade.

Depending on the dissected tissue, the blade can have various forms: thin-bladed, sharp-tipped, ducts or abscesses (Fig. 1).

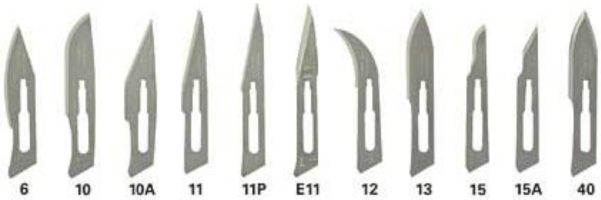


Fig.1. The four types of scalpel blade

The procedure also modifies, being defined two distinct cases:

1) *Long incisions:*

The scalpel has to be held like a fiddle bow, the handle being gripped horizontally between the thumb and the middle fingers with the dominant hand; the index finger offers precision and is staying above the handle; the ring and little fingers are placed towards the end of the handle (Fig. 2). The non-dominant hand puts the skin under tension by using the thumb and index finger.

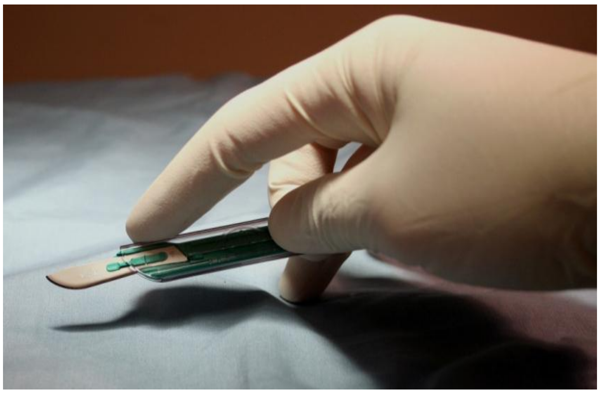


Fig. 2. Holding the scalpel for a long incision

1) *Short incision:*

The scalpel has to be held like a pencil, while the cutting occurs mostly with the tip. The handle is being grabbed approx. 3-4 cm from where the blade meets the handle. (Fig. 3)

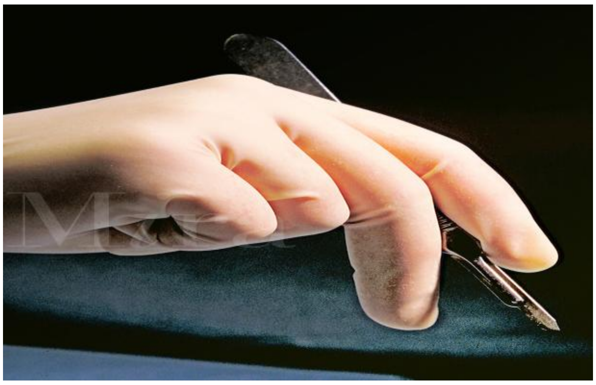


Fig.3. Holding the scalpel for short incision

Scissors are another important cutting device, that come as well in numerous forms, differing not only through the blades (straight, curved, angular), but also through the tips (blunt-blunt, blunt-sharp, sharp-sharp). Even if the blades and tips suggest the tissue intended to be cut, the same technique applies for all the surgical scissors. The thumb and the fourth finger have to be placed each in a ring, while the index finger is placed distally, over the handle, in order to stabilize the scissors. It is relevant to mention that a similar procedure is applied when operating with the majority of the clamps. (Fig. 4)


Fig. 4. Correctly holding scissors

The dissector is another cutting device that is long-handled and ring-ended. A unique characteristic is that usually it is bended at an angle of 90° at its distal part (Fig. 5). However the technique that is being performed while using a dissector is similar to the scissors.


Fig. 5. The distal part of a dissector

Needles and needle holders represent the most important system of tissue unifying, suturing. The most used needle holders are Mathieu and Hegar. Mathieu has curved shanks, a spring and different locking mechanisms (Fig. 6). It is hold like a pencil and should be compressed by the thumb and index finger. Hegar is similar to the homeostatic forceps, but having longer shanks and shorter jaws (Fig. 7). It is gripped similar to the scissors in the first phase and then rotated at an angle of 180° (Fig. 8).

Fig. 6. Mathied needle holder

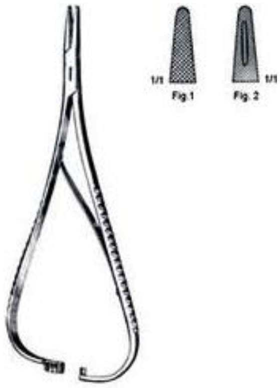


Fig. 7. Hegar needle holders

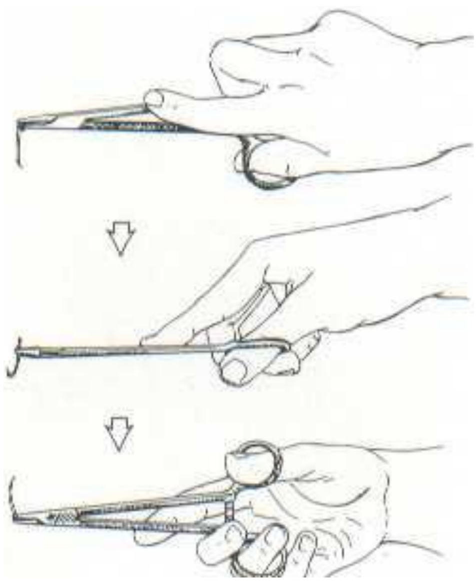


Fig. 8. The method of using Hegar needle holders

The needles are the active part of suturing. They are classified diversely:

- According to the diameter;
- Having a natural or synthetic wire;
- Having an absorbable or non-absorbable wire;
- Being traumatic or atraumatic;
- Being conventional closed or French eyed;
- In cross section circular or cutting;
- Shape: ½ of a circle, 3/8 of a circle, ¼ of a circle, 5/8 of a circle, J shaped, Ski shaped, multi-bended, straight.

There are many types of suture that can be performed depending on the tissue operated or the intended resistance. However there are two main types of suture:

- *Interrupted*: simple, vertical mattress, Allgower, horizontal mattress;
- *Continuous*: simple, locked, intracutaneous, purse-string;

The simple interrupted suture (Fig. 9) is usually performed on skin fascia and muscles. Its main principle is that after each knot is tied. Ideally the skin is undertaking an equal amount of tension with each suture. Even if it is time consuming the doctor has the guarantee that the suture will remain closed.

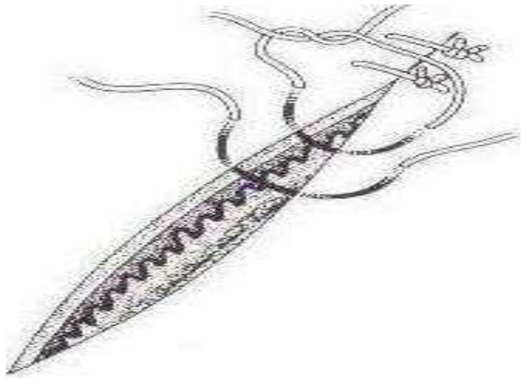


Fig.9. The simple interrupted suture

The vertical mattress suture (Fig. 10) occurs in the deep layers of the skin and is called either Donati or Vertical U-shaped. It is performed on a vertical plane perpendicular to the wound and consists of the deep suture in the subcutaneous layer and a superficial one on the surface of the skin, at the wound edge.

The Allgower suture is a subcategory of vertical mattress suture, but differentiates itself by not coming out from the skin (Fig. 11).

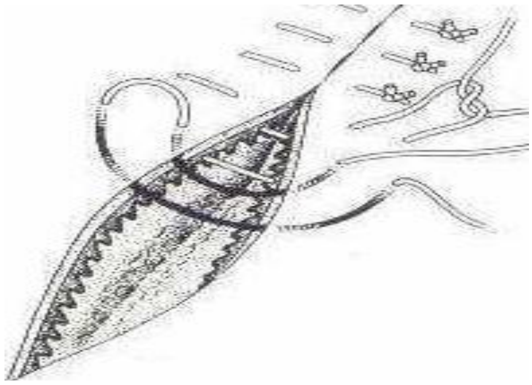


Fig.10. The vertical mattress suture

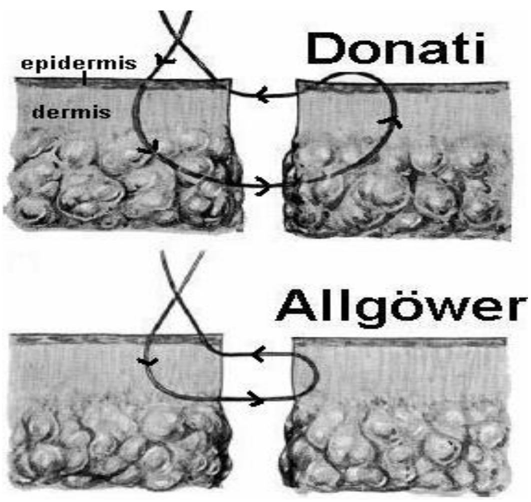


Fig. 11. Comparison between the Donati and Allgower suture

The horizontal mattress suture (Fig. 12) is normally used for a short skin wound. It is a double suture, in the same skin layer, made every one cm.

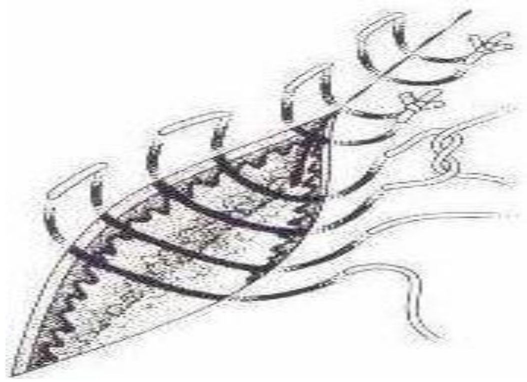


Fig. 12. The horizontal mattress suture

The simple continuous suture (Fig. 13) can be used for multiple types of tissues such as the inner wall of organs, the stomach, the intestines, and the mucosa. It is extremely time-efficient as it only requires two knots, one at the beginning and one at the end. Moreover, surgeons do not worry about the tension applied as it distributes equally upon the entire suture.

The locked continuous suture (Fig. 14) is an improvement brought to the simple continuous suture, as the external locks allow for the wound tension to be quickly and accurately adjusted, but also prevent the sutures to loosen.

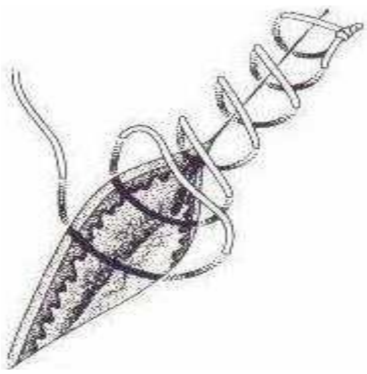


Fig. 13. The simple continuous suture

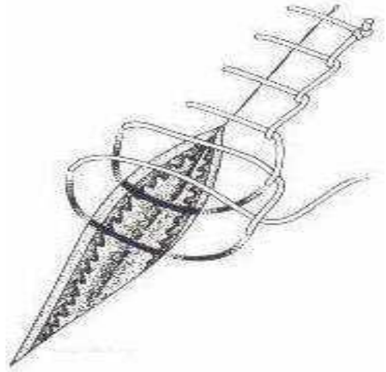


Fig. 14. The locked continuous suture

The intracutaneous suture (Fig. 15) is parallel to the skin surface and enters the skin at the beginning and only exists at the end. It takes an aesthetically pleasing form as it reduces the dimensions of the scar.

The purse string suture (Fig. 16) is only used for cylindrical, circular wounds such as the gastro-intestinal tract. It runs continuously around the opening. Afterwards, the edges are pulled together with a dressing forceps and the threads are knotted.

Fig. 15. The purse-string suture

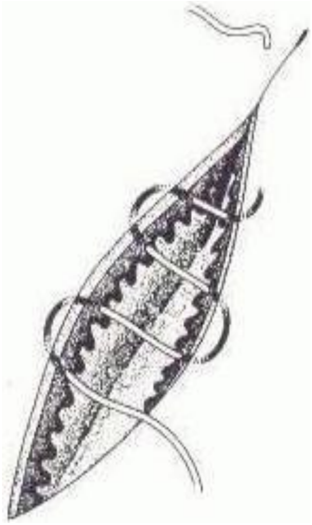
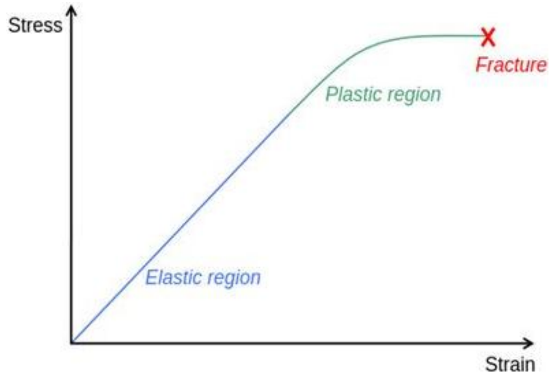


Fig. 16. The intracutaneous suture

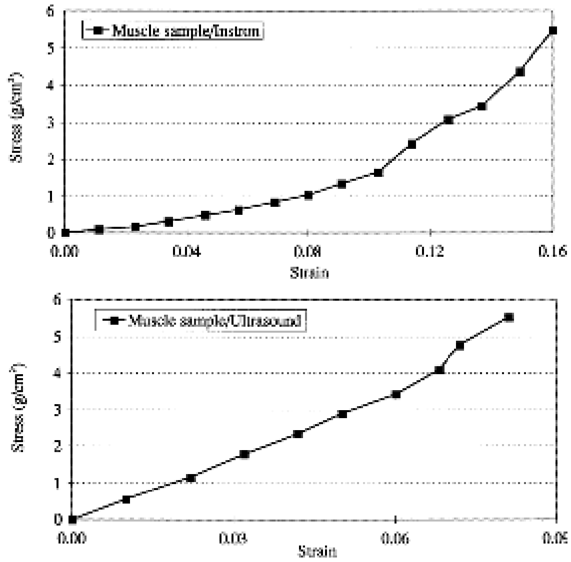
V. MICROBIOMECHANICS OF THE TISSUE

In order to understand the procedures occurring during a surgery, a comprehensive study of the microbiomechanics of the tissue is required. The forces that action upon specific tissues are: compressive (tend to deform the tissue by compressing them), flexure(tend to deform the tissue by bending them), torsion(tend to deform the tissue by twisting them), shear(result from combining the 3 forces mentioned above) and tensile(tend to deform the tissues by stretching them). Deformation or strain can be described as being elastic(reversible) or plastic(irreversible). Out of all the mechanical properties it is important to mention the viscoelasticity- integrates both elasticity and viscosity- of the tissue determined by the Young Modulus (E) as it determines from what point a deformation becomes plastic and afterwards fractures (according to Hooke's Law $\sigma=E*\varepsilon$, where σ is the applied stress and ε the resulting strain). (Graph. 1)

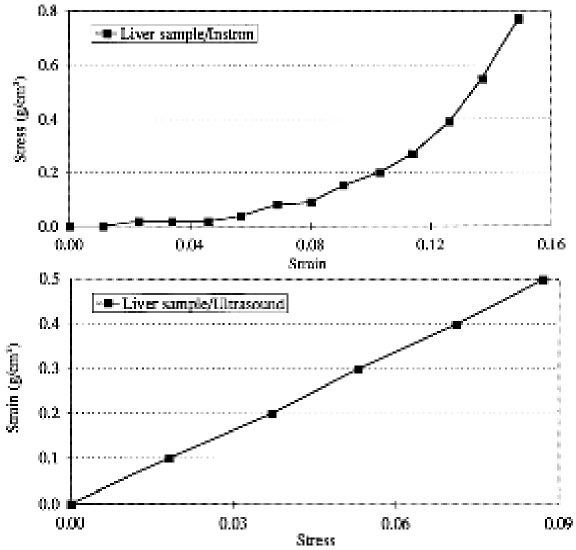


Graph. 1. General stress-strain curve

The stress-strain curves were further analyzed by numerous scientists to determine the Young Modulus for specific tissues. For accuracy and observation the researchers used two methods - with Ultrasound technology and Instron.



Graphs. 2, 3. The stress-strain curve for the muscle tissue using both methods



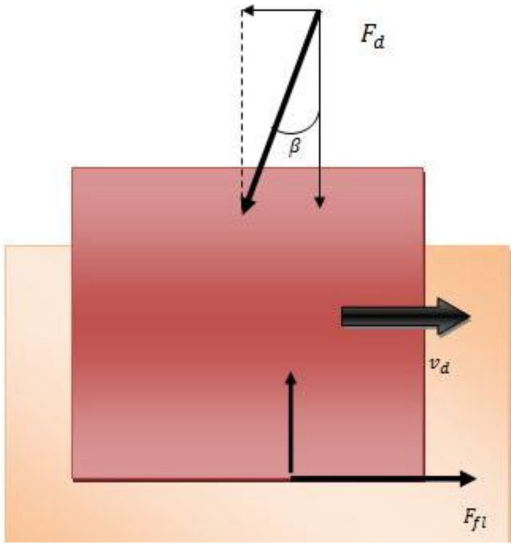
Graphs. 4, 5. The stress-strain curve for the liver tissue using both methods

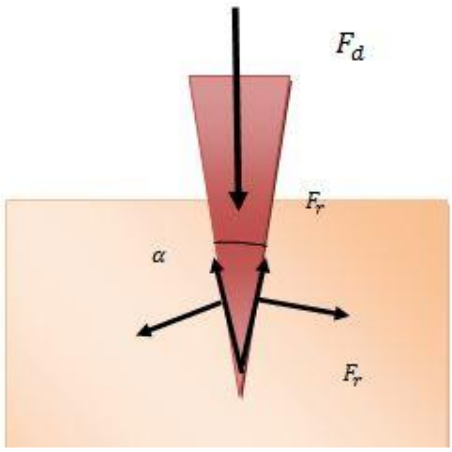
VI. METHODS OF ANALYZING THE ACCURACY OF A SURGEON

TABLE I. The ultimate tensile strength of different soft tissues.

Material	Ultimate tensile strength [Mpa]	Ultimate tensile strain [%]	Collagen (% dry weight)	Elastin (% dry weight)
Tendon	50-100	10-15	75-85	< 3
Ligament	50-100	10-15	70-80	10-15
Aorta	0.3-0.8	50-100	25-35	40-50
Skin	1-20	30-70	60-80	5-10
Articular Cartilage	9-40	60-120	40-70	-

Furthermore, we have developed a study of the incision of the scalpel through a soft tissue, where equations are included, in order to determine the force applied to the tissue.





(Ox)

$$-F_{fl} - F_{ft}\cos\left(\frac{\pi}{2}-\frac{\alpha}{2}\right) + F_{ft}\cos\left(\frac{\pi}{2}-\frac{\alpha}{2}\right) + F_d\cos\left(\frac{\pi}{2}-\beta\right) + F_r\cos\left(\frac{\alpha}{2}\right) - F_r\cos\left(\frac{\alpha}{2}\right) = 0 \quad (1)$$

(Oy) $$F_d\cos\beta - 2F_{ft}\cos\frac{\alpha}{2} + 2F_r\cos\left(\frac{\pi}{2}-\frac{\alpha}{2}\right) = 0 \quad (2)$$

$$F_{fl} \cong \mu_{bt} F_d \cos(\beta)$$

$$F_{ft} \cong \mu_{bt} F_r$$

After studying in depth the basic surgical techniques, instruments and the biomechanics of several types of tissues, we have developed systems that are able to identify the steadiness of a surgeon's hand or the pressure that is applied upon the tissue. This systems track the motion of needles, scalpels and clamps.

A. Tracks of the scaple

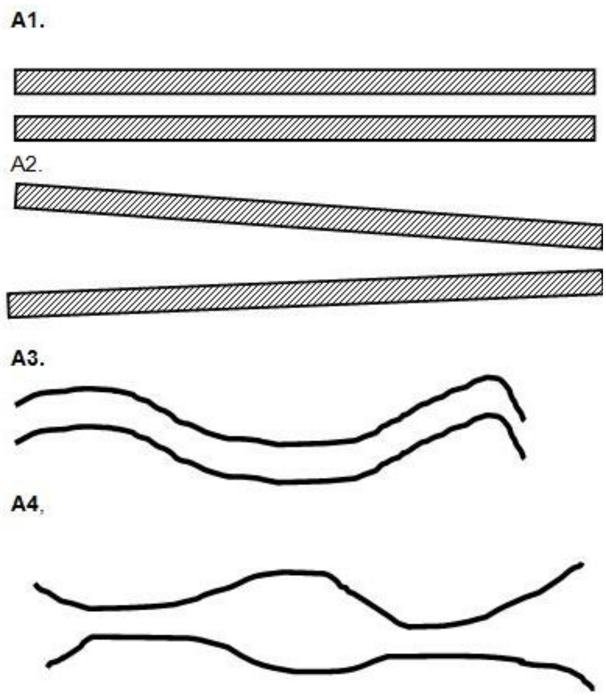
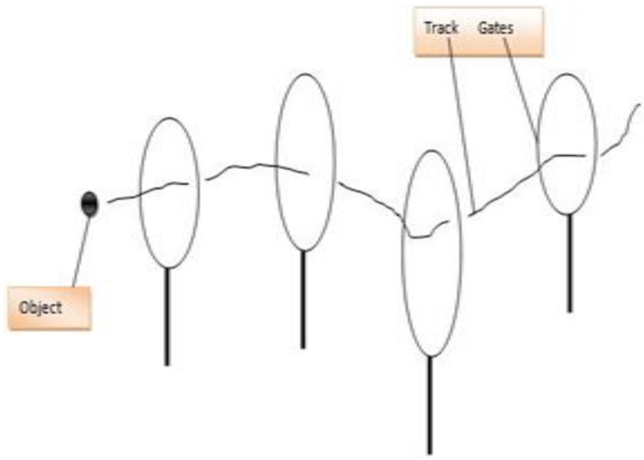


Fig. 17. Experimenting on gradual tracks for the scalpel

B. Randomtracks of transport with the clamp



C. Tracks of transport of networks at equal distances

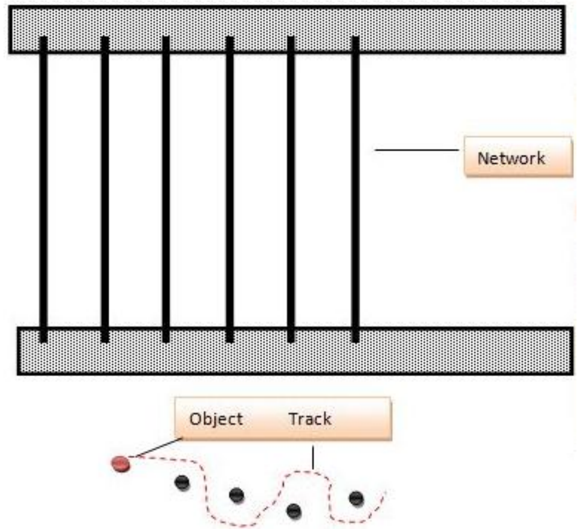


Fig. 18. Performing experiments on tracks of transport at equal distances

VII. CONCLUSIONS

We believe that the prototypes that we developed, of course perfectioned, could be of great use in teaching hospitals and Medical Universities as they can not only asses a surgeon's precision but also benefit the students by practicing and developing more and more their surgical ability.

Our prospects are to analyse more of the mechanical parameters of the tissue and reflect this knowledge and thus broaden our spectrum of applications in other systems that could be perhaps capable of sensing the pressure redirected to the tissue.

VIII. ACKNOWLEDGMENTS

We want to thank the National Institute for Research and Development in Electrical Engineering ICPE-CA and in particular our mentor, Mircea Ignat, for the support and materials offered.

As well, we want to mention our class teacher, Claudia Preda, as she was very responsive and appreciative towards our research theme.

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X. BIOGRAPHIES

Andra Maria Ciutac is a student in the last year of "George Cosbuc" Bilingual High School. She will continue her studies at Manchester, where she will be studying medicine.

Carmen Gabriela Popa is also a student in the last year at the same high school. She will be studying computer science at University Politehnica of Bucharest.

They have previously been working on a research project about the movements of the eye, obtaining numerous awards at national competitions. In May 2017 they will represent Romania at the International Olympiad of Applied Sciences Intel ISEF, which will take place in Los Angeles.

Microsensors Monitoring Devices Regarding the Rehabilitation Process Carried Out after Orthopedic Surgeries of the Lower Limb

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Abstract **-** The paper presents a set of monitoring devices with piezoelectric sensors that will help improve the quality and shorten the period of medical rehabilitation of the lower limbs, after orthopedic surgeries.

Index Terms - component, medical rehabilitation, piezoelectricity.

I. INTRODUCTION

Realizing that the rehabilitation monitoring and correction devices for patients going under orthopaedic surgeries of the lower limb are minimal we decided to tackle the subject and try to help. At the moment, the methods used to determine the stage of rehabilitation are mainly trivial and subjective, being based on the knowledge of the doctor, rather than on exact measurements.

The main medical recommendation we address is "walking with partial weight bare"(meaning not to force their limb over the imposed pressure limit). Since there has not been developed any mean of quantifying this pressure while walking and performing daily life activities outside the hospital, the process often takes more time and complications might occur.

There are 4 medical conditions that we plan to address:

- Recovery after surgeries:
  - **Fractures of the lower limb**

Every year, around 1.6million hip fractures occur and by 2050, studies alert that it will rise to 4.5-6.3million cases.

- **Artificial implants for the lower limb**

Needed due to osteoporosis or direct blows to the bone affected.

- Recovery during:
  - **Osteoporosis**

After the age of 50, 1 in 3 women and 1 in 5 men are affected.

- **Osteoarthrosis**

Around the world 50 million adults are affected, and, by 2030, nearly estimations show 67million people will need treatment.

Our project includes:

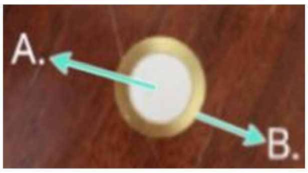
- **a set of "carpets"** with piezoelectric sensor attached, meant to be used in the initial phase of the rehabilitation process in order to decide a base value, in order to decide the recommendations;
- **a monitoring and correction device** made of **a pair of second insoles with piezoelectric sensors**, that will grant the patient the freedom to carry out his daily life activities outside the hospital;
- an **ARDUINO UNO platform** that received information from the sensors, analyses them and if the value is higher than the maximum recommendation it is transmitted to **a second ARDUINO UNO** where a buzzer generates a sound signal in order to warn the patient of this overcoming and a LCD screen displays the number of total steps vs. the number of "wrong" steps;
- **2 Bluetooth modules (HC-05 and HC-06)** that work as a pair (master-slave) and grant the connection between the two Arduino platforms and transmits the series of data.

Our future plans are to add a memory SD card to the second Arduino, in order to save and store the data received on a longer period of time, in order to be easier for the doctor to analyse them.

PRODUCT	PROCESS
‣ accessible ‣ efficient and accurate in measurements ‣ comfortable and easy-to-wear ‣ does not imply risks (electrocution, flames, accidents) ‣ offers a personalised base for future estimations, recommendations and research	‣ runs without interruptions ‣ answers in real time at the signals received ‣ monitors -> attentions -> corrects ‣ easy to understand for the user and it does not need further changes ‣ it can be adapted for the certain needs of the patient
DOCTOR	**PATIENT**
‣ helps to create personalised models based on the information given ‣ helps in monitoring the progess outside the hospital and the rehabilitation problem ‣ grants the chance to carry out studies from several data sets form a group of patients ‣ can study different patterns based on the condition affecting the patient	‣ offers the chance to have a second process of rehabilitation ‣ helps psychologically speaking, in order to regain their trust ‣ helps to understand the real need of respecting the doctor's recommendation ‣ does not stop him from performing his daily life activities

II. MATERIALS

A. Piezoelectric Sensors



Piezoelectric sensors are sensors used to convert pressure, temperature or acceleration differences into measurable electric potential.

They are formed of:

- **Piezoelectric crystals:**
  - Work similar to a conversion device- when a mechanical force is applied, they generate electric potential;
  - Used to transform mechanical energy into electrical energy;
  - Found in nature in crystals (quartz, topaz) or wood, sugar cane and tendons.
- **A solid base:**
  - Protects the crystals and dictates the top and bottom side.
- **A soft cover:**
  - Protects the crystals and allows it to charge only from one side, therefore not creating dangerous electrical tensions.

The piezoelectric effect is the ability of some material to generate an electric potential as a reaction to a mechanical force applied.

It can occur in 2 ways:

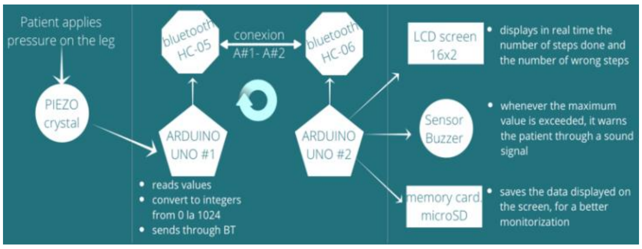
- **Direct piezoelectric effect:**
  - Mechanical pressure applied polarizes the crystal and generates an electric signal.
- **Indirect piezoelectric effect:**
  - When an electrical potential passes through the sensors, it suffers a mechanical deformation.

B. Electronic Components

Electronic components are used for assembling the wireless monitoring device that replaces the measurement devices (oscilloscope, data acquisition) and generates the sound warnings.

- **Arduino UNO x2**
  - We choose the open-source platform Arduino UNO because it is one for the beginner-friendly platforms and its coding language is similar to the one used for C++.
  - It has a small dimensions base built around the processor and it can receive signals from various types of sensors and work with the given data.
- **Buzzer**
  - Or the sound alert we chose to work with a brick mini speaker known as a "buzzer". It is directly connected to the main base of the Arduino in order to generate the sound.
- **LCD screen**
  - The LCD screen is compatible with the Arduino, being connected to the base. It can show up to 32 characters displayed on 2 rows on a blue light background.
  - It will be placed on the second Arduino, in order to show the total number of steps vs. the number of "wrong" steps.
- **Bluetooth modules (HC-05 and HC-06)**
  - Our devices must be patient friendly and flexible so we divided our components into two parts: the first Arduino with the piezoelectric insole connected and the second Arduino with the screen and buzzer connected.

We connected the 2 Arduino boards in the most efficient way we found: through Bluetooth modules (HC-05 and HC-06) that work as "master-slave".



III. EVOLUTION OF THE DEVICE

A. Piezoelectric Carpets

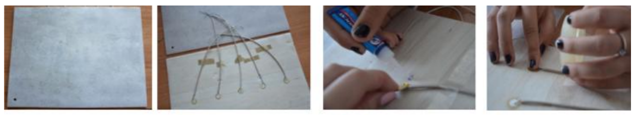


fig 1. the material fig 2. the sensors fig 3. fixing the wires fig 4. fixing the sensors

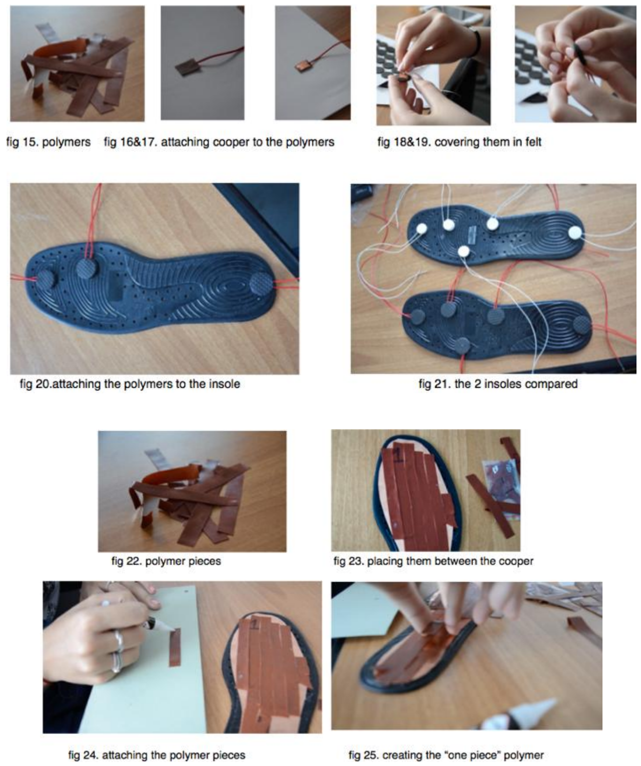
fig 5. the carpets ready to assemble fig 6&7&8. sticking them together fig 9. the final versions

B. Piezoelectric Silicone Insole

fig 10. The silicon insole fig 11. the sensors in felt

fig 12&13. Applying the sensors on the insole fig 14. The final

C. Polymer Insole

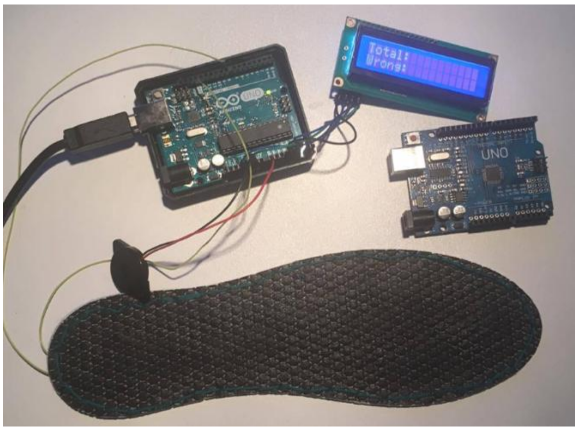


IV. DEVICE PROGRAMING

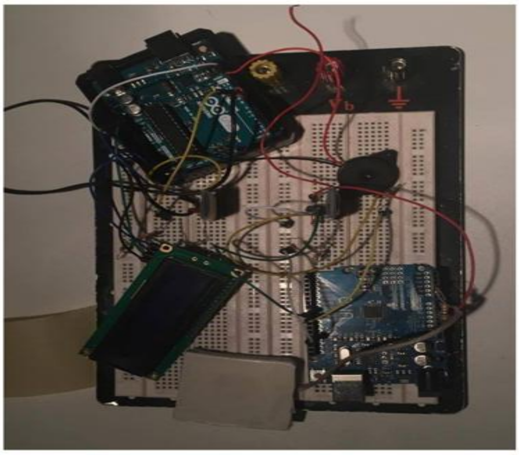
For the programming part, we chose the Arduino program, the standard application for Arduino devices.

In the code shown below the second Arduino (with the buzzer and LCD connected) are programmed so that when they get a signal from the insole, they classify it into two categories:

- if it's below the maximum set, add it to the total number of steps;
- if it exceeded the maximum, add it both to the total number of steps and the "wrong" steps and generate the sound signal.



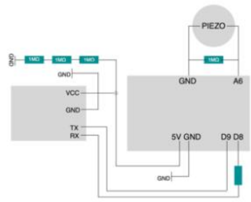
In the state we are now, we wanted to code the most optimal program so it can be easily worn. In the first phase, the Arduinos and the Bluetooth modules were set on a test-board. With the help of and electronic engineer we are going to fix the wires on smaller boards so they can be worn and be comfortable for the patient, but also accurate in measurements.



a. Arduino UNO SLAVE programming

```
#define prag 1000
#define timpApasare 10
#define intarziere 100

#include <AltSoftSerial.h>
AltSoftSerial BTserial;

int piezo = 0;
int i;
void setup()
{
  Serial.begin(9600);
  BTserial.begin(9600);
  Serial.println("BTserial started at 9600");

}
```

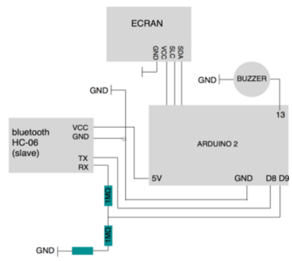
```
void loop()
{
    piezo = analogRead(A6);
    Serial.println(piezo);

    if(piezo > prag)
    {
      i++;
    }

   if(i == timpApasare)
   {
     BTserial.print(1);
     i=0;
     delay(1);
   }
```



b. Arduino UNO MASTER programming

```
#include "Wire.h"
#include "LiquidCrystal.h"
#include <AltSoftSerial.h>
LiquidCrystal lcd(0);
AltSoftSerial BTserial;
int valoare;
int i = 0;
void setup()
{
    Serial.begin(9600);
    pinMode(13, OUTPUT);
    digitalWrite(13,LOW);
    lcd.begin(16, 2);
    lcd.setBacklight(HIGH);
    BTserial.begin(9600);
}
void loop()
{
  valoare = 0;
    if (BTserial.available() > 0)
    {
      valoare = BTserial.read()-48;
```

```
if(valoare == 1)
{
 tone(13, 10000);
 Serial.println("Forta mare
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("Atentie!");
 delay(5000);
 noTone(13);
 i++;
}
lcd.setCursor(0,0);
lcd.print("Numarator pasi");

lcd.setCursor(0, 1);
lcd.print("Nr erori:");
lcd.setCursor(14, 1);
lcd.print(i);
```

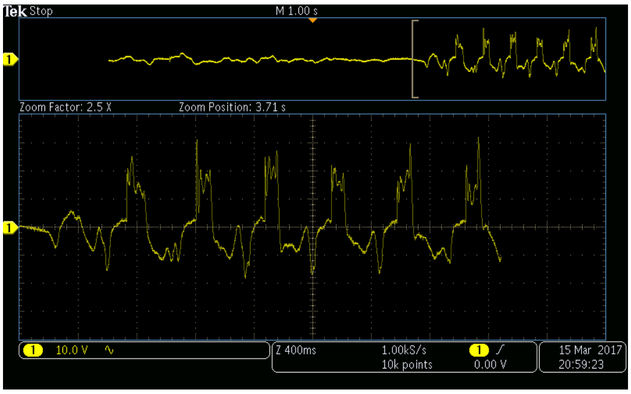


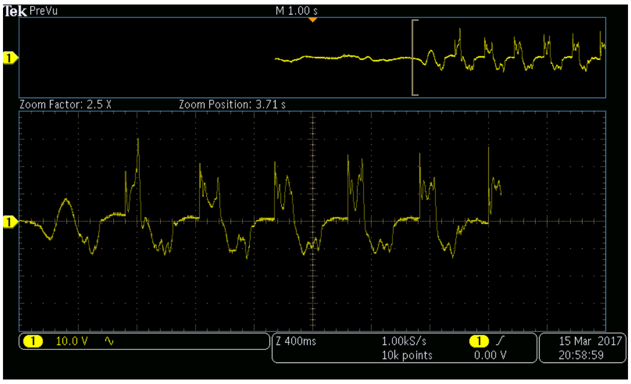
V. EXPERIMENTS

We performed a set of experiments with the piezoelectric insole connected to the oscilloscope in order to understand how the piezoelectric sensors work and observe the differences 2 people have while performing the same task.

- **Jumping**

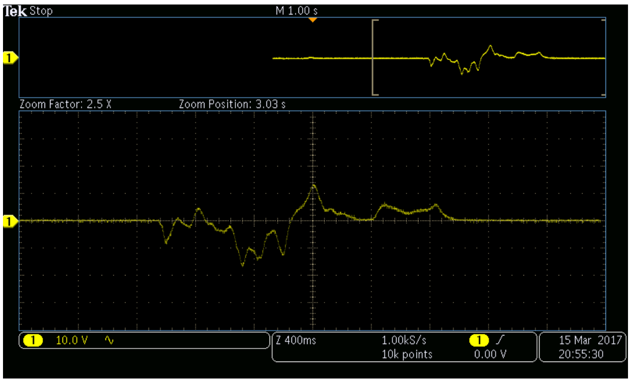
TASK: jump up and down on both legs;
PARTICIPANTS: authors of this paper;
OBSERVATIONS: From the two images extracted while measuring the signals generated when jumping, we can observe that even if the task was the same, the specifics of each person and the mark differ from case to case.

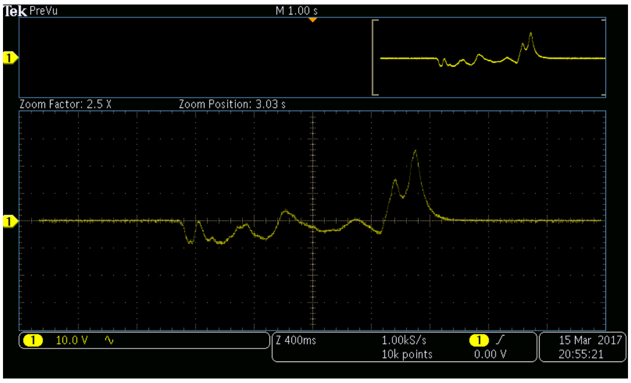




- **Walking in forward and backward**

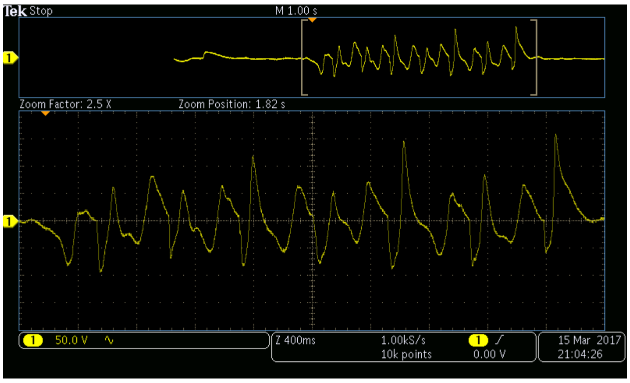
TASK: walk forwards and backwards;
PARTICIPANTS: authors of this paper;
OBSERVATIONS: Both images belong to the "signature" of the same person- walking forwards and backwards and the differences can be notice while comparing the peaks and the bottoms of the voltage measured.

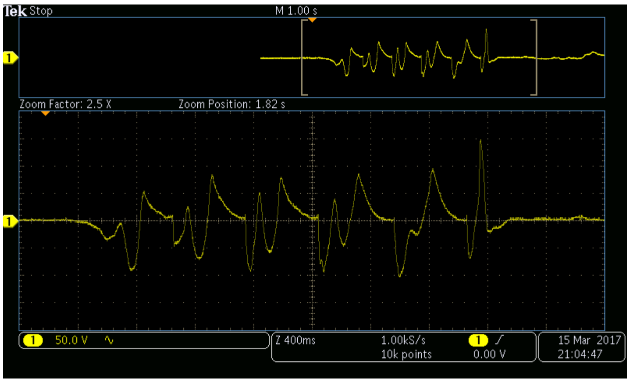




- **Walking in forward and backward**

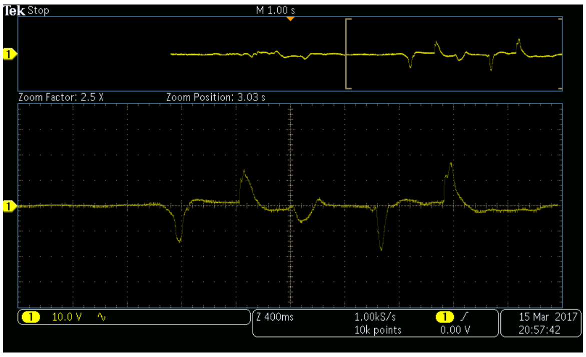
TASK: sequence of jumping on one leg (right in both cases);
PARTICIPANTS: authors of this paper;
OBSERVATIONS: In the pair of pictures below, the differences between the "signatures" are highly noticeable, and the multiplication of the signals displays that the jumps were almost equal, characteristic specific for healthy people.

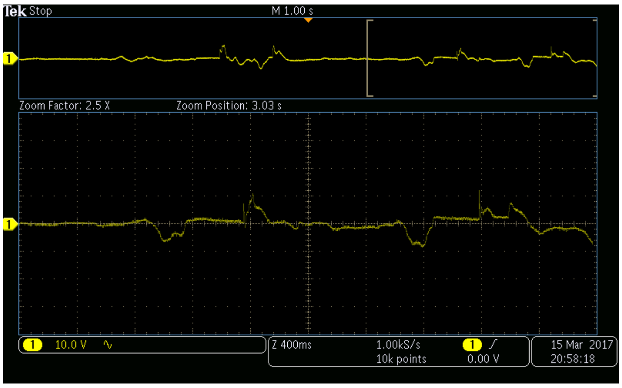




- **Walking in forward and backward**

TASK: set of two steps;
PARTICIPANTS: authors of this paper;
OBSERVATIONS: The following pictures display a sequence of two consecutive steps, performed by the authors of this paper, in order to emphasise on the differences that occur for 2 healthy people performing the same task.

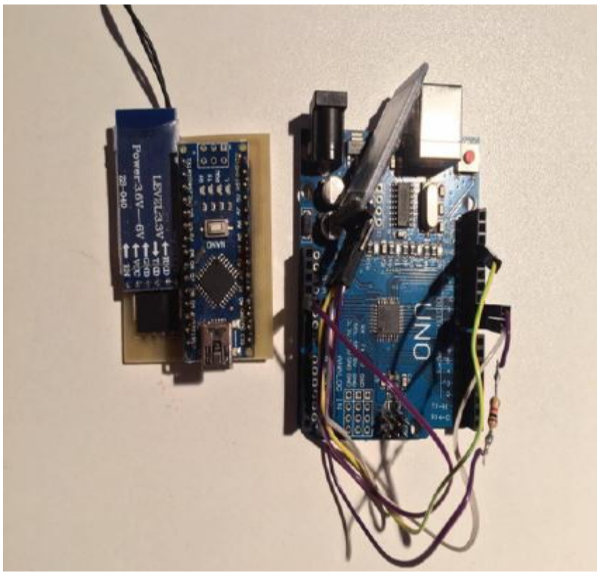




VI. PROTOTYPE

After sever trials, we re-designed the electrical components, creating the most compact version we could in order to make it comfortable for the patient.

Following the number of changes performed, we believe that the differences are quiet striking and easily observed both in terms of dimension, of practicability and of safety.



a. Ankle device

Advantages

- Smallest dimensions achievable in this state;
- Comfortable to wear on the ankle;
- Replaced wires with copper connections;
- Accurate measurements.

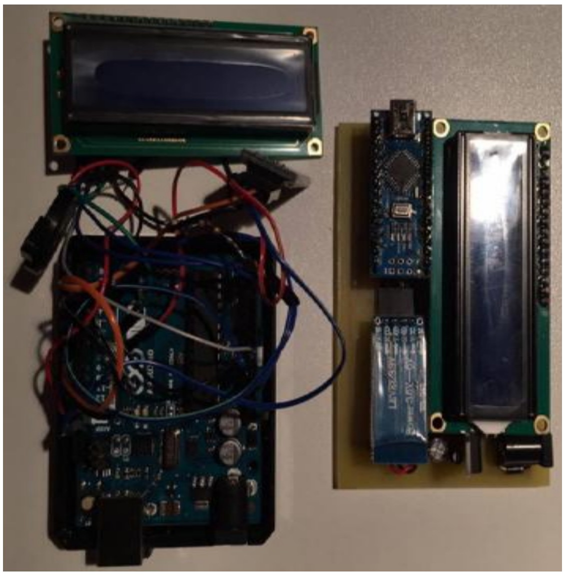
Disadvantages

- The battery must be separate.

Dimensions

length: 5 cm;
width: 4 cm;
height: 1.5 cm.

b. Pocket device



Advantages

- Robust design and easy to carry piece;
- Safe piece that does not imply any risks;
- Accurate measurements;
- Replaced the wires with copper connections.

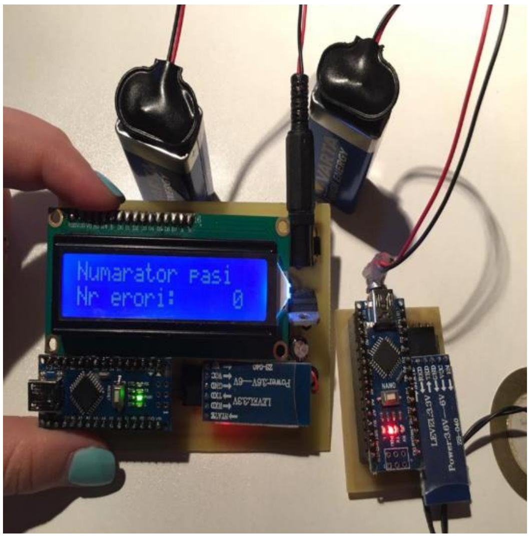
Disadvantages

- The battery must be separate.

Dimensions

length:10 cm;
width: 6.5 cm;
height: 2.5cm.

c. Final electronic component



The purpose of the ankle device is to receive data from the second insole and whenever the signal exceeds the maximum value decided, it sends it through Bluetooth to the second device.

The purpose of the pocket device is to receive data from the first part of the device, generate de sound warning and monitor the number of total steps per formed in total and the number of "wrong" steps.

VII. CONCLUSIONS

We believe that with our work so far we have achieved most of our initial goals.

ENGENEERING GOALS:

- Create a robust, safe and reliable device to fulfil the requirements;
- Assure that the hazard level (electrical, physical) is minimal;
- Designed a reliable real-time connection to warn the patient whenever stepping wrong.

SCIENTIFIC IMPROVEMENT GOALS:

- Provide a reliable track of the progress, measured, processed and stored for latter analysis or statistics;
- Grant the chance to create a data basis of progress tracks based on the monitoring sequences performed.

SOCIAL IMPACT GOALS:

- Improve the patient's morale by allowing him to track his progress and correct his mistakes;
- Grant confidence, trust and positive mind-state.

MEDICAL GOALS:

- Help doctors quantify the rehabilitation progress better both in and outside the hospital
- Help patients individually record their progress
- Conduct a series of long-term experimental measurements with a group of patients.

VIII. FUTURE PLANS

- Create a safe and robust carrying cover for the ankle device and an easy to carry cover for the pocket device;
- Add a micro SD card besides the LCD screen in order to save the data;
- Optimizing the product to be financially accessible;
- Contact a series of specialists regarding the device's applicability.

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X. BIOGRAPHIES

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- Golden medalist at Infomatrix National Phase (2014) at Hardware Control.

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- Golden medalist at Infomatrix National Phase (2014) at Hardware Control.

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- World finalist representing Romania at Intel ISEF2016 in Phoenix, Arizona.

Preparation of a Formatted Technical Paper for the Bulletin of Micro and Nanoelectrotechnologies

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Abstract **-** This document is itself an example of the desired layout (inclusive of this abstract) and can be used as a template. The document contains information regarding desktop publishing format, type sizes, and typefaces. Style rules are provided explaining how to handle equations, units, figures, tables, abbreviations, and acronyms. Sections are also devoted to the preparation of acknowledgments, references, and authors' biographies. The abstract is limited to 150 words and cannot contain equations, figures, tables, or references. It should concisely state what was done, how it was done, principal results, and their significance.

Index Terms - The author shall provide up to 10 keywords (in alphabetical order) to help identify the major topics of the paper and to be enough referenced.

I. INTRODUCTION

This document provides an example of the desired layout for a published MNE technical paper and can be used as a Microsoft Word template. It contains information regarding desktop publishing format, type sizes, and typefaces. Style rules are provided explaining how to handle equations, units, figures, tables, abbreviations, and acronyms. Sections are also devoted to the preparation of acknowledgments, references, and authors' biographies.

II. TECHNICALWORK PREPARATION

Please use automatic language check for your spelling. Additionally, be sure your sentences are complete and that there is continuity within your paragraphs. Check the numbering of your graphics (figures and tables) and make sure that all appropriate references are included.

A. Template

This document may be used as a template for preparing your technical paper. When you open the file, select "Page Layout" from the "View" menu (View | Page Layout), which allows you to see the footnotes. You may then type over sections of the document, cut and paste into it (Edit | Paste Special | Unformatted Text), and/or use markup styles. The pull-down style menu is at the left of the Formatting Toolbar at the top of your Word window (for example, the style at this point in the document is "Text"). Highlight a section that you want to designate with a certain style, and then select the appropriate name on the style menu.

B. Format

If you choose not to use this document as a template, prepare your technical work in single-spaced, double-column format, on paper A4 (21x29.7 centimeters). Set top, bottom margins and right margins to 15 millimeters and left margins to about 20 millimeters. Do not violate margins (i.e. text, tables, figures, and equations may not extend into the margins).

C. Typefaces and Sizes

Please use a Times New Roman font. (See your software's "Help" section if you do not know how to embed fonts.) Table I is a sample of the appropriate type sizes and styles to use.

TABLE I. Table name will be written in Times New Roman font.

Micromotor Code	b [mm]	a [mm]	h [mm]	Material
MPR33	33	25	20	PZT 5
MPR27	27	18	9	PZT 5
MPR15	16	10	10	PZT 5

D. Section Headings

A primary section heading is enumerated by a Roman numeral followed by a period and is centred above the text.

A primary heading should be in capital letters and bolded. The standard text format is considered times new roman 12.

The paper title should be in times new roman 20 uppercase and lowercase letters, not all uppercase.

Author name is set to times new roman 12, institution and contact address (E-mail) are set to times new roman 10.

Financial support should be acknowledged below the author name and institution. Example:

This work was supported in part by the U.K. Department of Defence under Grant TX123.

A secondary section heading is enumerated by a capital letter followed by a period and is flush left above the section. The first letter of each important starting word is capitalized and the heading italicized.

Tertiary and quaternary sections are accepted only in special cases, so usually must be avoided in order to keep a clear article structure. If required, a tertiary and quaternary section heading must be italicized and enumerated by adding an Arabic numeral after each letter.

E. Figures and Tables

Figure axis labels are often a source of confusion. Try to use words rather than symbols. As an example, write the quantity "Torque," or "Torque, *M*," not just "*M*." Put units in parentheses. Do not label axes only with units. As in Fig. 1, write "Torque (cNm)" not just "(cNm)". Do not label axes with a ratio of quantities and units. For example, write "Current (A)," not "Current/A." Figure labels should be legible, approximately 10-point type.

Large figures and tables may span both columns, but may not extend into the page margins. Figure captions should be below the figures; table captions should be above the tables. Do not put captions in "text boxes" linked to the figures. Do not put borders around your figures.

All figures and tables must be in place in the text centered and written with times new roman 10. Use the abbreviation "Fig. 1" in sentence and for each figure name. Each table must be defined as „TABLE I", with capital letters and roman numbers.

Digitize your tables and figures. To insert images in Word, use: Insert | Picture | From File.

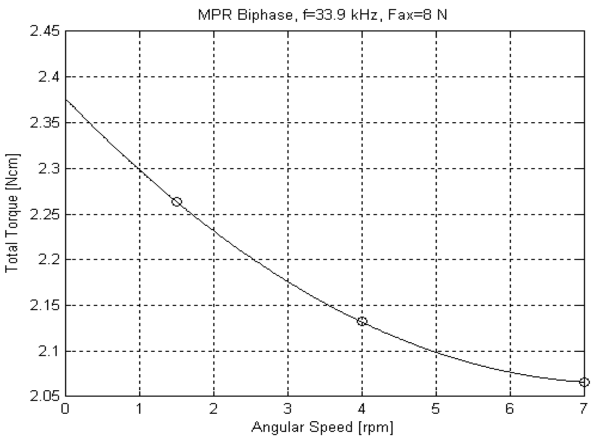

Fig. 1. Total torque function of angular speed. (Note that "Fig." is abbreviated and there is a space after the figure number)

F. Numbering

Please number reference citations consecutively in square brackets [1]. The sentence punctuation follows the brackets [2]. Multiple references [2], [3] are each numbered with separate brackets [1]-[3]. Refer simply to the reference number, as in [3]. Do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] shows….".

Number footnotes separately with superscripts (Insert | Footnote). Place the actual footnote at the bottom of the column in which it is cited. Do not put footnotes in the reference list. Use letters for table footnotes.

Check that all figures and tables are numbered correctly. Use Arabic numerals for figures and Roman numerals for tables.

Appendix figures and tables should be numbered consecutively with the figures and tables appearing in the rest of the paper. They should not have their own numbering system.

G. Units

Metric units are preferred in light of their global readership and the inherent convenience of these units in many fields. In particular, the use of the International System of Units ("Système International d'Unités" or SI Units) is advocated. This system includes a subsystem of units based on the meter, kilogram, second, and ampere (MKSA). British units may be used as secondary units (in parentheses). An exception is when British units are used as identifiers in trade, such as 3.5-inch disk drive.

H. Abbreviations and Acronyms

Define less common abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Standard abbreviations such as SI, CGS, AC, DC, and *rms* do not have to be defined. Do not use abbreviations in the title unless they are unavoidable.

I. Math and Equations

Use either the Microsoft Equation Editor or the *MathType* commercial add-on for MS Word for all math objects in your paper (Insert | Object | Create New | Microsoft Equation *or* MathType Equation). "Float over text" should *not* be selected.

To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize symbols for quantities and variables. Use a long dash for a minus sign or after the definition of constants and variables. Use parentheses to avoid ambiguities in denominators.

The number of each equation must be consecutively added in parentheses and arranged at the right margin, as in (1). Be sure that the symbols in your equation have been defined before the equation appears or immediately following.

Don't use "Eq. (1)" abbreviation instead of "equation (1)", in a sentence.

$$L_m = \frac{m}{A^2} \tag{1}$$

with m - mechanical mass, A - force factor, L_m - electromechanical inductance.

III. ACKNOWLEDGMENT

The following is an example of an acknowledgment.

The authors gratefully acknowledge the contributions of Mircea Ignat and Puflea Ioan for their work on the original version of this document.

IV. APPENDIX

Appendixes, if needed, appear after the acknowledgment.

V. REFERENCES

References are important to the reader; therefore, each citation must be complete and correct. There is no editorial check on references, only the format Times new roman 10 must be considered.

[1] Satanobu J., Lee D.K, Nakamura K., Ueha S., "Improvement of the Longitudinal Vibration System for the Hybrid Transducer Ultrasonic Motor", IEEE Trans. On Ultrasonic ferroelectrics and Frequency Control, vol. 47, no. 1, January 2000, pp. 216-220.

[2] Morita T., Yoshida R., Okamoto Y., Kurosawa M., "A Smooth Impact Rotation Motor Using a Multi-Layered Torsional Piezoelectric Actuator", IEEE Trans. On Ultrasonic ferroelectrics and Frequency Control, vol. 46, no. 6, November 1999, pp. 1439-1446.

VI. BIOGRAPHIES

A technical biography for each author must be included. It should begin with the author's name (as it appears in the byline). Please do try to finish the two last columns on the last page at the same height. The following is an example of the text of a technical biography:

Mircea Ignat was born in Bucharest on March 4, 1953. He graduated at 1977 and he received PhD degrees in electrical engineering from Bucharest Polytechnic University in 1999.

His employment experience included the National Institute for Research and Development in Electrical Engineering ICPE-CA, Microelectromechanical Department and he is the coordinator of "Alexandru Proca" Center for the Youngsters Initiation in Scientific Research.

The research preoccupation include: the synchronous generators and the high speed electric machines. He is member of IEEE.