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Content

Aleksandra Maria Osowska-Kurczab, MSc Eng – 1st Prize of the XIII Ed. PTIB Competition (2019)

DIFFERENTIATION OF THE RENAL CANCER TYPES BASED ON THE ANALYSIS OF CT IMAGES

Abstract: The purpose of this study was to investigate different methods applied in automatic analysis of the computer tomography scans in order to differentiate types of kidney tumours. The experimental research was conducted on a dataset consisting of 8 types of renal cell carcinomas: angiomyolipoma, carcinoma chromophobicum, carcinoma clarocellulare, multilocular cystic carcinoma, oncocytoma, papillary carcinoma, papillary urothelial carcinoma and renal cystis.

The fundamental task of this study was to create a system, which would be able to predict one out of eight types of kidney tumours on the basis of a full scan from CT delivered on its input. It is assumed, that tumour location on CT scan is known (segmentation task was not considered during the experiments). The performed analyses were based on a broad spectrum of research fields such as data analysis, data mining, machine learning, deep learning and digital signal processing. This study explores various methods of training dataset generations, class balancing (including data augmentation) and image normalization.

The study was concentrated on two methods of image classification: the deep learning approach and textural representation of CT scans supported by final classification using a support vector machine. It has been demonstrated that both these techniques have great potential for application in the automatic medical imaging classification task. Particularly, very promising results have been obtained in the classification of randomly chosen images from the testing set. Classification accuracy of such systems reached the level of 90%. The best results of the ensemble formed by 10 deep AlexNet structures have reached the value of F1 measure equal 88.7%. Similar results of 89.46% have been obtained for fractal textural model combined with Support Vector Machine.

The results of this study might find application in supporting the medical diagnosis in hospital procedures. Implementation of such a system in automatic medical images analysis could lead to a significant acceleration of the diagnosis process and to better prioritization of patients waiting for consultation with medical specialists.

Keywords:
medical imaging, deep learning, data mining, neural networks, Support Vector Machine, image classification, renal cell carcinoma

Wiktoria Wojnarowska, MSc Eng – 2nd Prize of the XIII Ed. PTIB Competition (2019)

ANALYSIS OF PEEK APPLICATION IN KNEE ENDOPROSTHESIS MODELING

Abstract: Due to the increasing longevity of human life, the lifespan of endoprostheses is aimed to be as long as possible to avoid the need for replacement. The weakest component of a knee replacement is the polymer insert [1]. Therefore, increasing the lifespan involves improving the strength properties of this component. This can be achieved by replacing the previously used material with another.

This study aimed to analyze the possibility of using one of the considered materials, i.e., polyetheretherketone (PEEK), to produce knee inserts. The first stage of the research was to compare PEEK and ultra-high molecular weight polyethylene (UHMWPE) on the basis of literature data. The next stage was the reconstruction of the geometry of the knee joint affected by pathological changes, which included isolation of individual bone structures and model simplification. The next stage was the fabrication of the individual knee joint implant using computer techniques such as CAD modeling and fabrication methods. The created model was subjected to dimensional and shape verification carried out using a 3D optical scanner. The final stage was a finite element analysis of selected load cases of polymeric inserts differing in the material. The simulation was carried out to study the influence of the forces induced during the patient's movement on the concentration and values of stresses along with the deformation of the insert depending on the material used.

The comparative analysis concluded that the mechanical properties of PEEK are more similar to those of bone than UHMWPE. In addition, PEEK is superior to UHMWPE in many respects. It has better mechanical strength and does not change its properties under thermal and radiation sterilization. One of the results of the study was a physical model of a custom-made knee insert. On the other hand, based on the simulation results, it was found that higher stresses, as well as strains, occurred in the insert made of UHMWPE. It follows that the insert made of PEEK is less susceptible to changes in geometry, so it would be less likely to be overloaded due to disruption of the joint geometry. The highest stress concentration in the knee inserts occurs on their bearing surfaces, which are typical failures for insert failure. However, it should be noted that the yield point was not exceeded in any of the cases analyzed, despite the high value of the loading forces. However, it should be noted that in none of the analyzed cases the yield strength was exceeded, despite the high values of the loading forces.

In conclusion, it was found that PEEK is suitable for making a polymeric insert element for knee replacement. Its use could prolong the life of this element and, consequently, of the entire endoprosthesis. Furthermore, since the highest concentration of stresses in the knee insert occurs on its load-bearing surfaces, indicating that this is the part of the insert that is most prone to failure, it would also be possible to extend the life of the insert by strengthening only these vulnerable surfaces.

Reference::

[1] Gierzyńska-Dolna M., Biotribologia, Wydawnictwo Politechniki Częstochowskiej, Częstochowa 2002.

Paweł Czekała, MSc Eng – 3rd Prize of the XIII Ed. PTIB Competition (2019)

CONSTRUCTION OF A VOICE COMMUNICATION DEVICE IN PRODUCTION CONDITIONS FOR DEAF PEOPLE

Abstract - Summary: The subject of the masters' thesis deals with one of key aspects of functioning of the unit in a group, communication, without which both professional and personal life would be exposed to a number of misunderstandings and complications. For people with auditory disabilities, a process of communicating with hearing people in a manufacturing company is especially difficult, therefore an attempt of creating a prototype of a glove cooperating with a mobile application, which task will be to translate sign language into text and speech was made.

In first two chapters the main target and assumptions, that were posed by the authors and consulted with the promoter, are described. In next chapter focus was placed at analysis of literature, especially considering specifics of using sign language in manufacturing environment and technological possibilities used in this project as well as in existing solutions. In the following part of this thesis the methodology was featured, starting with conception of solution and ending with ways of carrying out tests on finished device. Last two chapters present and sum up effects of every stage that was made during this project.

Krzysztof Andrzej Gromada, MSc Eng – 2nd Distinction of the XIII Ed. PTIB Competition (2019)

CONSTRUCTION AND RESEARCH OF PULSE PUMP WITH MAGNETO-HYDRAULIC LEVITATION APPLIED TO ARTIFICIAL HEART

Abstract: The goal of this thesis is to analyse, design, construction and conduct a preliminary research of a physical model of a pulse pump with magneto-hydraulic levitation. The main issue studied is the ability to maintain magneto-hydraulic suspension of the internal piston. Due to the proposed use as a support or replacement of a human heart, blood/blood-mimicking fluid must be considered as a medium in both calculations and experiments.

The first chapter contains a simplified description of the tested pump model and various natural factors that have to be considered in the design of the device. Thanks to this, it is possible to present an operating principle and a proper work cycle. The expected advantages of the construction are: preventing/lowering stagnation, reduced damage to the blood cells, lack of a mechanical friction between pump elements. The chapter is supplemented with the most used mathematical models of blood, current heart supporting pumps and characteristics of biocompatible materials, which described device must be made of.

The following chapter defines the goal and the scope of work. It also introduces Elmer software. This freeware enables the calculation of magnetic vectors based on the finite element method. A detailed description of the pump, according to a patent, is also provided in this unit.

The next part summarizes the preparation of the design and construction of the test stand with the first pump model composed of a set of magnets and a piston is described. At the beginning the basic kinematic and dynamic parameters, that should be achieved by the final construction, are determined. Then, the applied mechanical elements are calculated, including valves, piston, gears, as well as magnets and media used in the test. The project also includes alternative materials and potential improvements. Systems for controlling and adjusting the set of drivers are also described.

The results of the work are presented in the chapter dedicated to the description of the test method, results of experiments and conclusions resulting from former steps. This part also contains pictures showing the obtained meta-stable magneto-hydraulic levitation.

The conclusions of all stages were summarized at the end of the thesis. A feasibility study, a list of advantages and disadvantages with the final conclusions were discussed.

Keywords: Artificial heart, rapid prototyping, bio-engineering, magneto-hydraulic levitation

Agnieszka Dubiel, MSc Eng – 3rd Distinction of the XIII Ed. PTIB Competition (2019)

ATTEMPT TO DEVELOP A TECHNOLOGY FOR THE PRODUCTION OF PERSONALIZED PLOYLACTIDE PLATES FOR BONE ANASTOMOSIS REINFORSED WITH GLASS FIBER

Abstract: Looking at the statistics of bone fractures, we notice an upward trend, especially when we analyze such cases as traffic accidents and osteoporotic fractures. The break in the continuity of the bone structure occurs as a result of excessive loads exceeding the limits of bone strength. The main method of bone fixation, especially difficult and complicated fractures, is to stabilize the bone with a metal implant in the form of a bone plate. This element stabilizes the bone fragments until the bone fuses. In most cases, such an element has specific shapes and dimensions, which results in inadequate adaptation to the patient's bones, which does not provide good bone stabilization. Additionally, the use of a metal implant may lead to an allergic reaction or prolonged inflammation within the implant. Typically, allergic reactions are caused by corrosion or degradation of metallic biomaterials. In particular, this applies to elements such as: Fe, Cr, Ni, Al or V. Taking into account the ever-dynamic development of 3D printing and personalized implants in the thesis, it was proposed to create a prototype of a bone plate. The proposed solution is to adapt to the size and shape of the patient's bones in order to stabilize the fracture in the best possible way. The plate structure was made in the form of a polylactide (PLA) composite and reinforced with a glass mat of two thicknesses: 25 g / mm2 and 110 g / mm2. In order to determine the mechanical properties, the samples were subjected to a strength analysis using a static tensile test and a static three-point bend test. The results of the research show that it is right to use glass cloth to strengthen polylactide. The tests showed an increase in strength when using a filling in the form of glass fiber. The research showed the possibilities of using reinforcements in 3D printing, making it possible to use such a solution to accelerate the rehabilitation of the patient after bone fusion surgery. In order to improve the properties in further tests, biocompatible materials with improved properties, e.g. carbon fiber, can be used.