**Using deep learning and sensory technologies for early detection and management of**

**learning disabilities and health conditions**

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**Introduction**

The topic of this study is “Using deep learning and sensory technologies for early detection and management of learning disabilities and health conditions”. Currently, the field of information technology is actively developing, we are introducing it into various processes, so another important and always relevant topic for humanity is medicine and healthcare [1]. In this study, we are studying the combination of information technology with medicine and how this synergy of spheres can be used to improve the convenience of humanity in different spheres, as well as to create and identify new, in-demand technologies.

The hypothesis of our research is that convenient and accessible technologies can be a contributing part to the overall improvement of people's health, maintaining health for patients and facilitating automated processes in medicine, helping healthcare professionals do their jobs.

Our topic promotes the search and identification for the use of computer science, engineering, and medicine to create and identify useful devices and technologies that already exist and improve them. We believe that if these devices are easy to use, easy to use, and adaptable to everyday life, then this can contribute to improvements in the fields of healthcare and automation. It turns out that the research is aimed at identifying and studying technologies that are at the intersection between the two fields of computer science and medicine

The context of our research is two areas: healthcare and medicine, but we are considering a fairly broad topic, and are not limited to a specific organization or place. In our case, a place can mean various healthcare institutions, and these include hospitals, medical centers, and clinics. If we take into account the people covered by the study, they include both medical workers and developers and engineers working on products of combined information and medical technologies. It turns out that we are also considering society, and this is treated as patients, that is, residents of the country, and workers in these two spheres.

First of all, with the help of the study we want to achieve an answer to our question about the totality of the fields of medicine and information technology, where the main factor is technology for use and consumption. There are also several goals that we want to achieve:

Explore:  
  
 - We want to find and define the most suitable and most convenient technologies that can contribute to the development of processes, improving the condition of people, which are widely available and easy to use.  
  
 - We are committed to exploring the possibilities that these technologies offer, how they can be used and applied

Clear description:  
  
 - We want to define technologies that address the issue of convenience and automation, describe and identify the relevant factors, as well as how they can benefit society, where they can be used, who they are suitable for and how difficult or easy they are to invent.

Understanding:  
  
 - We strive to understand which technologies are most useful and will have the greatest impact.

In general, our goal is that we want to find and describe those technologies from the fields of medicine and computer science that will be accessible to patients and help healthcare professionals do their jobs effectively.

The nature of the “Why” of our research question lies in our desire to solve pressing problems that arise in healthcare and harness the maximum potential of the field of information technology, which includes software, machine learning, Internet of things, neural connections, and computer science. In seeking to answer our research question, we are motivated by the fact that truly user-friendly technologies exist and can be applied in everyday life. Thus, “Why” is based on the desire to see the best results of the synergy of these areas, which will lead to quick tracking of the condition of patients or simplification of people’s lives both at work and during treatment, as well as quick diagnosis.

We have several potential connections that we would like to explore in this study. One of the most important is the impact on patient well-being.

-We want to determine exactly how the use of medical technologies can affect people’s condition.

-How technologies increase automation and efficiency, can they reduce the time workers and people wait for medical processes and services.

-We want to determine the correlation between accessibility and equality, that is, how accessible technologies must be in order for them to support or even lead to equality between people, whether technologies can be accessible to everyone, regardless of circumstances.

-Implementation. How interested and needed people are in these technologies, both consumers and manufacturers. What will motivate them to use these devices and technologies?

The social significance of our research lies in the fact that it has the potential to positively impact the lives of people from different spheres on a large scale. It turns out that by exploring the topic of accessible medical technologies, we can identify opportunities and solutions for solving social problems.

These include:

Health. The goal of the research is to make healthcare accessible by harnessing the potential of technology to simplify people's lives while improving their health.

Economic effect. Perhaps our research can help create more sustainable systems for treating and researching patients, and also reduce costs by constantly maintaining people's condition checks.

The result of the research can contribute to social progress in the field:

-Improved health indicators

-Speed of research

-Expanded access to medicine

Thus, our study has important implications from a social perspective. Its results can lead to improved healthcare delivery processes, operations, faster automation processes and improved health.

**Literature Review**

The combination of AI, machine learning, IoT, and sensor technologies is paving the way for significant advances in healthcare, promising better patient results, efficient disease management, and a comprehensive approach to medical treatment.

The rapid evolution of technology has greatly influenced healthcare and public health infrastructure. A significant emphasis has been placed on incorporating Soft Computing to enhance and optimize the healthcare domain, aiming to make it more adaptive and efficient [1].

Integration of Artificial Intelligence (AI) in healthcare diagnostics and treatment has seen significant advancements. Neural networks have shown promise in classifying cognitive test drawings, potentially revolutionizing cognitive examinations and making them suitable for telemedicine platforms [2].

Machine learning's potential in stroke medicine cannot be overstated. From precise diagnosis to personalized treatment selections, machine learning offers a paradigm shift in treatment outcomes [3].  
By analyzing MRI images it is possible to draw conclusions about stroke [3].

Oncology, too, has witnessed the incorporation of AI, especially in hybrid imaging. Such applications primarily focus on automating tasks, improving disease characterization, and integrating diverse data sources for a comprehensive understanding of cancer [4].  
Using ML and Based on several human analyses that would be time-consuming for doctors to analyze, it is possible to quickly predict cancers [4].

Specific ailments, like Parkinson's disease, have also been a focus. Automated methods are now being developed for early detection and severity prediction, aiding healthcare professionals in treatment planning [5].

Epilepsy monitoring has seen advancements with the combination of IoT and AI. Systems that predict and diagnose epileptic seizures promise effective monitoring and management of epilepsy [6].  
If IoT tools with sensors that pick up brain impulses are available, it will be possible to use different AI methods to monitor and manage epilepsy [6].

Similarly, wearable systems using LSTM-based neural networks are being developed for blood glucose prediction, offering a revolutionary approach to diabetes management [7].  
Using modern sensors on mobile phones, it is possible to measure blood sugar levels, monitor and manage diabetes more effectively, prevent complications related to irregular blood glucose levels and improve overall patient care and outcomes [7].

Lastly, the potential of deep learning in detecting learning disabilities through handwriting analysis stands out. Not only does this offer early identification and intervention for children facing such disorders, but tools like "SensoGrip" also offer real-world applications for early dysgraphia detection [8][9]

Using machine learning techniques, it is possible to detect cognitive disorders from images of people's drawings and handwritten manuscripts [2]. It is also possible to analyze children's handwriting for learning disabilities detection [8]. A more convenient way is a pen (“SensoGrip”) with a sensor inside that detects dysgraphia in children [9].

It has been proved that it is possible to predict cognitive diseases from patients' drawings, and the sensor pen will be more convenient to use [2][9]. In machine learning, the more data, the better the prediction result. Both approaches have not been tested on real patients and collected relatively small amount of data for testing. With machine learning techniques, we don't need to search for key points manually, the algorithm can find them on its own. We can select groups of people, collect data and then test the device. In addition, the SensoGrip study was limited to dysgraphia only, and the authors point out that it is possible to test predictions of other problems [9].

It is also possible to identify the stages of Parkinson's disease by analysing the speed and pressure of the pen when drawing a spiral [10]. The authors introduced a new index, the Composite Index of Pen Speed and Pressure (CISP), which combines these two parameters to more accurately assess the severity of the disease. This method can be related to our study, as we also use the images obtained during the spiral drawing process to be analysed using deep learning techniques.

**Problem:**

Our research addresses a problem in the medical field, namely the early detection and treatment of learning disabilities and health conditions, with a particular focus on Parkinson's disease. This disease and similar diseases have a great impact on a person’s quality of life. Definitely, in order to avoid the development of the disease, one of the best solutions is intervention and early diagnosis. Thus, we use modern information technologies that will help ensure prevention and create methods for detecting the disease, which will subsequently help us manage the method of treatment and examinations.

**Research Questions:**

* How well can computer models perform at recognizing diseases using photographs of people's drawings?
* If we set up a model to recognize drawings, could we detect Parkinson's disease?
* What computer models are best suited for disease recognition purposes?
* How can this model be used in the medical field?
* Using what indicators can we determine the reliability of the model?

**Methodology**

**Objective**

The main goal we set in our research is the use of deep learning and sensor technologies for the early detection and treatment of health disorders. At this stage, the emphasis is on Parkinson's disease and its detection using technology. Our methodology is structured using our data set as a basis. The dataset includes images that depict patterns such as drawing spirals or waves by healthy people or those diagnosed with Parkinson's disease.

**Data Preprocessing**

A mandatory step is data preprocessing, which is carefully designed to optimize the data set itself, which will subsequently be needed for model training. As described earlier, images are transformed by various methods such as enlargement or flipping, horizontal, vertical and rotation. To improve our model's ability to generalize to a variety of data, these additions were designed to introduce variability. All this leads to the reliability of the model, and in turn, for this it is necessary to consider the possibility of experimenting with other methods of changes, such as magnification, as well as Gaussian blur.

**Model Architecture and Training**

For this study, we used a convolutional neural network (CNN), namely the VGG16 model. It is very finely tuned for our specific dual classification problem. It is pre-trained on a large set of images. In general, it helps us distinguish objects in two ways among our data, namely drawings of healthy people and those with a Parkinson's diagnosis. At this stage, the model has good performance and fits our dataset. Of course, we check the reliability of its operation and for this we use a certain strategy, it helps us in the accuracy of the results, the strategy is called 5-fold cross-validation. It is currently the best for our needs and for our classification task.

**Mixed Methodology Application**

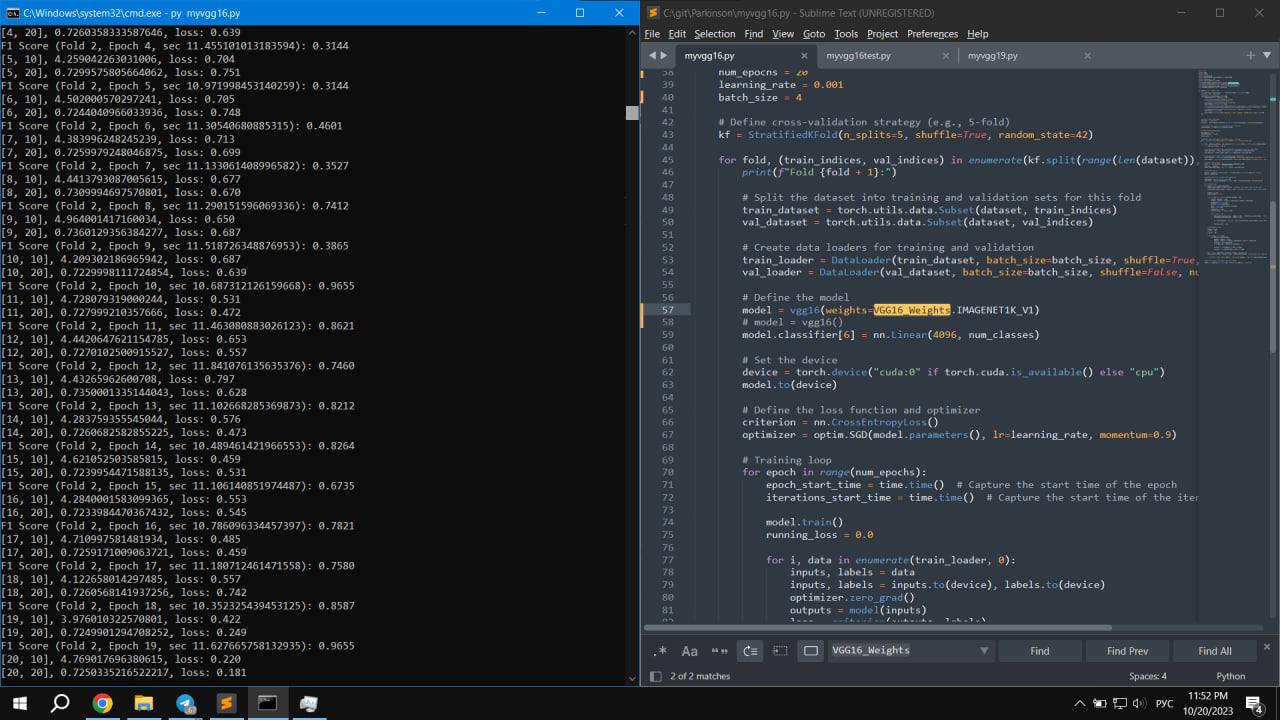
For our research, we use quantitative analysis, which means the presence of statistical calculations and working with digital data. Thus, we obtain the results in numerical form. But we do not exclude qualitative data. In this regard, an example could be expert opinions or subjective interpretations. It turns out that by mixing quantitative and qualitative approaches we strive to complete our research. In this way we get a more complete picture and in addition to the numerical factors, we have the opportunity to obtain human aspects regarding the research topic.

**Evaluation**

We take a multifaceted approach, in turn we use accuracy metrics as well as F1 score. This applies to all subsequent performance evaluations of our models. We consider this important point necessary because it provides the following definition of strength, and in addition to this we can also point out points and areas where, on the contrary, more effort can be applied and the model can be improved.

**Implementation**

In order to fully implement our methodology, we use the PyTorch framework. We chose it because it has an extensive set of functions, which in turn help us implement many aspects and stages of our research, making them more efficient, such as data processing or model evaluation.

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**Sampling Methods**

**Stratified Random Sampling**

Our goal is to develop and validate AI and sensor-based tools and methods to detect and manage various diseases, in particular cognitive impairment and dysgraphia, and for this task we decided to choose stratified sampling as the most appropriate sampling method.

We can divide our general population into different strata (e.g. people with dysgraphia, people with cognitive impairment, healthy people, etc.). We can then randomly select samples from each stratum to train and test our models.

This method ensures that each subgroup is represented in your sample, which is especially important if you are investigating different diseases or conditions.

Also, given that we can test the predictions of other problems, we can consider expanding the study to other diseases or conditions using the same sampling method.

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