A PHYSIOTHERAPY CONSULTATION APPLICATION FOR SPORTS

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DECLARATION

This project proposal is my original work and has not been presented for a degree in any other University

……. ……..

Signature Date

This project proposal has been submitted for examination with my approval as University Supervisor

…… …….

Signature Date

ABSTRACT

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CHAPTER ONE

1. INTRODUCTION

1.1. BACKGROUND

Physiotherapy is a medical branch that is mostly concerned with body movement and enhancing healthy living of an individual using body motions. According to Bogdan (2006), physiotherapy has plethora of uses from scenarios such as helping a patient who has gone through major surgery or illness such as stroke achieve full recovery and get back their normal movements to enhancing performance in sport's individuals.

There are many branches of physiotherapy all for accomplishing different objectives. Sports and exercise physiotherapy is required by any player or athlete of any sport. It determines the success of a player and lack of it leads to lots of wasted potential. It is involved with the prevention and management of injuries resulting from sport and exercise participation at all ages and at all levels of ability, providing evidence-based advice on safe participation in sport and exercise, promoting an active lifestyle to aid individuals in improving and maintaining their quality of life, and helping athletes of all ages and all levels of ability to enhance their performance.

Roll ball is one of the team games that require physiotherapeutic intervention to keep the players in the team at their peak performance. The JKUAT sports department in conjunction with JKUAT hospital and physiotherapy students in the university have tried to provide this necessary service to the JKUAT roll ball team, and other varsity teams as well, but it is just not enough.

The health status of a player is just as important, maybe more important, as training. At the London 2012 Olympic Games, physiotherapists formed the largest professional group working at the Olympic Games. The essential role of the sports physiotherapist in international and elite sports (and in all other levels of sport, for that matter) remains to provide treatment and rehabilitation of injuries and to provide performance support through injury prevention, maintenance and recovery interventions. (Grant et al, 2014). As such, there need to be other solutions to help the JKUAT roll ball team get more physiotherapeutic help.

1.2. INTRODUCTION TO RESEARCH AREA

Artificial intelligence or AI for short is a way of providing a computer or a robot or simply some machine to think, process information and act on their own or in simple words providing the machines with an ability to think like a human (Charniak & Mcdermott, 1991). It can be looked at as the branch of computer science that is concerned with automation of intelligent behavior. (Lugar,2002). In simper terms, AI are machines or systems with the ability to adapt to changing environments and scenarios and learn from experience.

AI is quite broadly implemented in health care, for example, systems to help making faster diagnosis and giving basic medical feedback. AI can be designed and trained for a specific task, or AI can be designed for more general purposes covering different cognitive abilities that humans have, and thus, finding its own solutions for an unfamiliar task. (Rousse, 2019) AI

technologies such as image analysis with neural networks have been widely used in the medical field and physiotherapy, sports and exercise sector, has been no different.

Just like in any other field, AI in physiotherapy as grown from the point of confusion and doubt as to whether such incorporations are possible to now where AI-based robots, systems, or applications work with a physiotherapist (basically teaches patients proper exercises and make sure each movement is performed correctly) to provide a patient with better services. The job of a physiotherapist is often made very difficult when a patient is in the home environment as there is no way to monitor the patient. This gap has provided an opportunity of development of AI based solutions that work with physiotherapist to help patients.

Impeccable systems such as the Portuguese SWORD Health are a result of such developments. It uses wireless motion trackers that patients attach to their bodies and the data produced can be used to monitor and adjust patient's rehabilitation programs. (Correia et al, 2018). Among the list is Kaia Health; an app that tracks the motion of points on the body using an iOS or Android device's front-facing camera (Kylie, 2018), Physitrack; an app for iPads and iPhones that tracks patient exercise performance, adherence, and outcomes, and Bionlink robot; a mechanical rehabilitation device that work with hands, wrists, and arms, guiding the patient to perform the exact movement in the correct way and providing assistance as needed. These mechanical physical therapists can work collaboratively with humans helping the patient fine-tune each movement, while the therapists help the patient translate these improvements into greater function. (Michal, 2017).

AI will not entirely replace sports and exercise physiotherapists but it can be used to give sports people more control of the part of their health that matters the most to their career: mobility. Data produced by AI applications can be used to provide on-point, on-time physiotherapeutic intervention and personalizing the process of helping a player.

In the local aspect, consultation applications such as BYON8 (a joint Sweden and Kenya project), and M-Daktari are using AI to provide users with more control on their health matters. Although not much has been done particularly on AI in physiotherapy, more development and AI based solutions are to be expected in this field.

1.3. STATEMENT OF THE PROBLEM

The allocated physiotherapy students do not fully meet the needs of the roll ball team. First off, with over thirty team members to care for, the one or two provided physiotherapy students are just too overwhelmed to be effective. Moreover, sometimes teams are required to share the available students greatly reducing contact time the physiotherapist has with the team rendering their services ineffective due to unavailability. Second, being students, the physiotherapists cannot accord the team members the required attention to pull through an injury. Juggling studies and providing services for teams leaves them ineffective and unavailable. Third, the attempt to provide teams with physiotherapeutic services is also to provide extra training for the physiotherapy students who are not yet professional enough to handle the needs of a team, especially a contact game with so many members and potential for many injuries. Finally, most of the physiotherapy students are not invested in the game enough to understand the urgency and importance of helping a player get back in the game. Sports and

exercise physiotherapy is only as effective as the physiotherapist's love for the game the team is playing.

As a result of the above-mentioned inadequacies, most roll ball players end up taking way too long to recover from even minor injuries and some develop permanent change in mobility and muscle functionality. This adversely affects the players by cutting down training time and reducing performance of individual players and the team as a whole. Consequently, it reduces the number of players that can be selected to join the roll ball national team, the recognition the university can have in the roll ball games, and possible funding that could be directed to the university as a result of great performance from the roll ball game.

Given the magnitude of this challenge, additional ways are required to ensure the team has the required physiotherapy intervention. As the physiotherapy students are already overwhelmed, technology, such as AI-based consultation application, comes in handy to give the players more control on their performance matters and curb the issue of unavailability and ineffectiveness of the physiotherapists.

1.4. PROPOSED SOLUTION

This research seeks to develop an AI based physiotherapy consultation application. The application will use machine learning to provide personalized service and advice to a player. It will also allow for consultation with physiotherapists and provide a way to communicate to them. Moreover, it will have exercise suggestions to enhance players performance after analyzing the game and the muscles mostly used in playing. It will also store data that can be used when a player's medical history is required by a doctor of physiotherapist.

1.5. OBJECTIVES

1.5.1. GENERAL OBJECTIVE

- To develop a physiotherapy consultation application for the JKUAT roll ball team.

1.5.2. SPECIFIC OBJECTIVES

- To find out what has already been done in enhancing physiotherapy with technology.
- To understand the gaps technology can fill in the interaction of physiotherapists with their patients.
- To collect, analyze, format data to be used in training, testing and validating neural networks
- To investigate technologies used in video and image analysis.
- To find out if already available technologies such as AI powered mobile phone cameras can be used to enhance quality of consultation apps.
- To find out which development methodology is suitable for AI related projects.
- To test the efficiency of physiotherapy consultation apps and understand how they can help both the patient and the physiotherapist.
- To test the feasibility of physiotherapy apps for the JKUAT roll ball team.

1.6. RESEARCH QUESTIONS

1) How has the advancement of technology influenced physiotherapy and what is to be expected in the future of incorporating technology in physiotherapy?

2) What opportunities exists in the physiotherapy field to technology to provide interventions to?
3) Can existing videos of the roll ball team playing be used in neural networks and how can they used or made ready for use, and is there a need to use motion detectors in collecting data for the neural networks or there are alternate ways?
4) What technologies are used for video and image analysis and are they good enough to be used in the physiotherapy sector?
5) How can available technologies such as mobile phones with AI powered cameras and GPS be used to enhance the field of physiotherapy?
6) Can traditional methodologies such as the waterfall handle the AI projects or are more contemporary methodologies more suitable?
7) How helpful and efficient are physiotherapy apps to patients and physiotherapists and do they solve a problem or introduce unnecessary redundancy?
8) Do the advantages of a physiotherapy consultation warrant the resources used to make such an application?

1.7. JUSTIFICATION

This research was born out of experience of a challenge as a team member of the JKUAT roll ball team. According to Hindustan Times e-paper, roll ball was invented in 2003 and is still a fairly young game with less than 10 world cup competitions held. I joined the JKUAT roll ball team in 2017 as a freshman in university and has been a member for four years. Back then, we did not even have our own court for training and shared one with the JKUAT basketball ladies' team. There has been tremendous growth to this point where our main concern is to enhance a player's performance and deal with injuries. Our performance has sky-rocketed and both the ladies' and the men's team are at the top of the national league table as indicated in the Kenya National Roll Ball League website. However, more can still be done to better this performance as during the last roll ball world cup competitions, the team only contributed three players to the national team out of the possible twenty-four. With the use of physiotherapy, this number could be more.

The research will impact the team by enhancing performance of individual players hence the whole team. It will solve most of the injuries issues in the team and allow players to do more in terms of exercise to achieve peak performance. With the already available physiotherapy help, a consultation application will solve issues of unavailability and inefficiency by providing ubiquitous access to physiotherapy services and giving players control of mobility health.

1.8. RESEARCH AND SYSTEM METHODOLOGIES

1.8.1 SYSTEM DEVELOPMENT METHODOLOGY

Rapid application development is a systems' development methodology created to radically decrease the time needed to design and implement information systems. RAD relies on extensive user involvement, prototyping, integrated CASE tools, and code generators. (Valacich & George, 2017)

The approach has been selected because it will enhance fast project turnaround, by minimizing the planning stage and maximizing prototype development, or by reducing planning time and emphasizing prototype iterations, allowing stakeholders to accurately measure progress and communicate in real time on evolving issues or changes. This will result in greater efficiency, faster development, and effective communication in the project.

Phase 1: Requirements planning

This stage will involve meetings with the supervisor, and clients (software users), to determine the goals and expectations for the project as well as current and potential issues that would need to be addressed during the build. The following activities will be involved:

- Researching the current problem
- Researching on technologies to be used for the problem
- Coming up with a project proposal
- Getting approval for the project proposal
- Defining the requirements for the project
- Finalizing the requirements with each stakeholder's approval

Phase 2: User design

This stage will involve building out the user design through various prototype iterations with tools such as paper prototypes, mockups and storyboards, and working hand in hand with clients iteratively to ensure the system is meeting their requirements.

Phase 3: Rapid construction

Final agreed on prototype will be converted into the working model quickly as problems and changes have been handled in the iterative design phase. This will involve the following act ivies:

- Preparation for rapid construction
- Program and application development
- Coding
- Unit, integration, and system testing

The client will still get to give input throughout the process. They can suggest alterations, changes, or even new ideas that can solve problems as they arise.

Phase 4: Cutover

This is the implementation phase where the finished product will go to launch. It includes data conversion, testing, as well as user training.

Benefits of RAD methodology

- RAD allows the project to be broken down into smaller, more manageable tasks.
- Clients get a working product delivered in a shorter time frame.

- Regular communication and constant feedback between team members and stakeholders increases the efficiency of the design and build process.

1.8.2. RESEARCH METHODOLOGY

1.9. SCOPE

This research and development project is confined to producing a physiotherapy consultation application to the JKUAT roll ball team. It will be just for the ladies' and men's team and focus on injury prevention, management, and cure, and performance enhancement of a player through movements specific to the roll ball game. Although exercising and mobility practices are pretty much universal, it cannot be of much use to other teams as different muscles are used in different games and require different kind of attention.

CHAPTER TWO

2.LITERATURE REVIEW

2.1. INTRODUCTION

In today's era, AI-based research has led to the use of expert systems that guide clinical decision-making. Development of computer vision algorithms can outperform human beings in the analysis of CT and MRI scans providing better diagnostics and prediction of patient outcomes and enhanced administration and planning in health systems (Harwich,2018). Because of AI research, there are important advances in the areas of information retrieval and retention, problem-solving and reasoning, image recognition, planning, and physical manipulation (Frankish & Ramsey,2015). Predictive modeling where prediction of an event or outcome based upon the available data is done and can be a useful tool in providing preventive and immediate care for patients having certain conditions (AI & ML). Given the mind-boggling advancements and use of technology in the medical field, the goal of this review is to cover the advancement of technology in physiotherapy from what little technology served as the start of use of technology in the field, what has been achieved so far, and what is to be expected in terms of more application of technology in the field and the impacts of technology in the field. The review will also cover current gaps that technology can provide interventions to, how to collect and prepare data for AI in physiotherapy, the technologies used in video and image analysis, and general use of current technologies in physiotherapy.

2.2. CONCEPTUAL FRAMEWORK

2.2.1. ADVANCEMENT OF TECHNOLOGY IN PHYSIOTHERAPY

This will cover the history, current status, and the future of technology especially AI in physiotherapy. It will cover what has been done in the field of AI in physiotherapy and methodologies used.

According to Says (2018) devices such as electrical simulators were introduced to perform physiotherapy due to advent of computers in the healthcare industry in 1980. Since then, more advancements in the technology sector have led to more technological applications being incorporated in physiotherapy. "Stroke Recovery Predictor" is one such beautiful application developed by an Indian physiotherapy researcher to predict the extent of recovery of stroke patient based upon the details related to hospital stay duration, duration of stroke, Barthel index score (Stinear et al,2019). One more such useful application of AI based technology in assessment of posture of a patient is Open Pose, which is developed by a team of developers from India. It is an open-source library developed in C++ for the posture detection. It is used by importing open pose and later image is passed as NumPy matrices, which is then converted to human key points. It is combination of Caffee, OpenCV and OpenCL which is used for rendering of passed image. It is used in different fields such as hand gesture detection, Basketball games for prediction of basket throw and various other sports activities. It is also easier to use because of its capability to replace methods which involve high cost along with more equipment and time for processing (Godse et al,2019). Addition of "Chatbot" system in AI

based applications guiding the patients through rehabilitation can use cognitive therapy for understanding of psychology of patients for faster healing of them and to maintain regularity and thereby increases the adherence to treatment (Godse et al, 2019). It can also be able to keep track of their routines and it will chat with them on regular basis for collecting more data for processing of psychology. Thus, in addition to providing support to physiotherapist in diagnosis and treatment adherence, such system can help maintaining emotional stability of the human for healing (Vivek Ramanandi, 2020).

Technologies used in AI for physiotherapy currently include machine learning such as CNN, motion sensing, robotics, video and image analysis, and technologies incorporated in mobile devices such as GPS and camera.

These technologies and their use in the field of physiotherapy will bring changes the physiotherapy field. We need to understand and adjust to the fact that 21st century healthcare systems will be patient-driven and that care teams will be cross-disciplinary, loosely connected, and will be including smart machines empowered with AI(Vivek Ramanandi, 2020). Fundamental reforms to how we think about professional practice are necessary for preparing graduates for clinical practice in the 21st century rather than iterative changes to our current clinical and educational paradigms (Wartman & Combs,2019). Patients will be at the center of every aspect of their health having more control and driving how this fields develop while physiotherapists will need to adjust to remain relevant.

Most applications developed in this area have involved intensive research combing various fields to come up with solutions acceptable and safe to users. most of the teams use agile methodologies of system development due to the dynamicity of their undertakings and incorporation of different programming languages, libraries (such as OpenCV, OpenCL, OpenPose, Luminoth, and Detectron), data collection and analysis techniques, and fields (Feng, nd).

2.2.2 DATA COLLECTION, ANALYSIS, AND PREPATION METHODS.

Data for AI models in physiotherapy can be from a range of sources such as real-time videos as in the Kaia app, videos and images from motion sensors and wearables, and existing videos. Videos can be collected using cameras of different mobile devices. Whatever the source of data, it has to be formatted in order to be used by the model for training, testing and validation. According to Vidhya (Video Analysis Using Python | Deep Learning on Video Data, 2018), videos and images are handled the same way in a model as a video is just a series of images or frames. However, videos have to go through an extra process where images or frames are extracted from the video and labeled before being fed to the model (Alaloul & Qureshi, 2020).

2.3. SYSTEM REVIEW

2.3.1 KAIA

Information derived from one of Kaia's pitching presentations reveals that it is an AI-based physiotherapy multimodal consultation application that provides real-time and remote access to the most effective back pain therapy digitally scalable to the mass. Multimodal exercises include physical exercises, psychological exercises, and physical education. It offers personalized, adaptive service as it is based on machine learning (Kaia Health grabs $75M on surging interest in its virtual therapies for chronic pain and COPD, n.d.).

Figure 1. UI of the Kaia Application.

ADVANTAGES

- Personalization of user experiences that gets better as they continue using the application.
- The application reduces cost by eliminating wearables and motion sensors that would require additional cost on the part of the user to incorporate and depends on inbuilt device cameras.

- Real-time help and analysis of the users' movement.
- Multimodal healthcare.
- Incorporation of specialists that are available to the user.

DISADVANTAGES

- People in dire need of the application might not know of the application unless informed by the physiotherapists.

2.3.2 SWORD HEALTH

SWORD health is a virtual musculoskeletal care provider that uses sensors, a tablet, and a physical therapist you see via telemedicine. You can do one of their 100+ exercises at home, and their Digital Therapist uses data from the sensors to give you live feedback (SWORD Health and Virtual Musculoskeletal Care, n.d.).

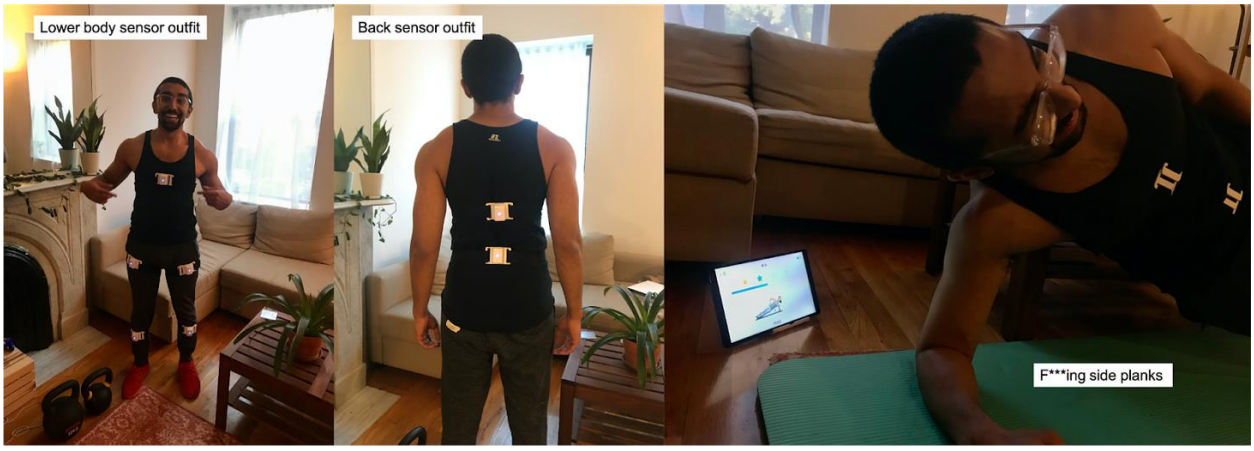

Figure 2. A user using the SWORD system.

ADVANTAGES

- Physiotherapist can monitor their patient exercising at home.
- Data from the application is made available to the physiotherapists and can be used to device more help.
- Users can reduce physical visits to their physiotherapists and still get enough contact time.
- Guidance through the process of performing exercise.

DISADVANTAGE

- Users have to acquire more devices including a tablet working only with the SWORD application, and the wireless wearable motion sensors.
- The physiotherapists still do pretty much everything including monitoring, and tweaking exercise regimen for the user.

2.3.3 PHYSITRACK

This is an app for iPads and iPhones that tracks patient exercise performance, adherence, and outcomes (Artificial Intelligence in Physical Therapy: Cool Applications, Fascinating Implications,

2020). It boosts patient engagement with crystal-clear, fully narrated exercise videos, education and outcome measures delivered straight to your client's smartphone or computer (Physitrack Cliniko Integration, n.d.).

Figure 3. Supported functionalities by the application.

ADVANTAGES

- It tracks outcomes in real-time
- It has secure Telehealth video calls powered by Dolby, where exercise videos can be directly live streamed to users to ensure correct technique at all times during treatment by physiotherapists.

DISADVANTAGES

- It is more centered on helping the physiotherapists than the users.

2.4 SUMMARY

A lot has been done in terms of incorporating AI based solutions in physiotherapy and these can be transferred to sports and exercise physiotherapy. Due to the mismatch in the numbers of sportsmen and the currently available physiotherapists, sports' individuals could gain a lot from applications that is centered on them and can work without a specialist unless there is dire need. The advancements made are so far very impressive and players can expect to be catered for in the near future.

2.5 RESEARCH GAPS

AI in physiotherapy has evolved from use of intelligent robots to help a patient in the home environment, to use of wearables to track patients motions during exercise in corporation with a physiotherapist, to consultation mobile based apps that fully utilize device capabilities in providing patient-driven service. However, more could still be done to provide patients more personalized experience. Kaia is still researching how 3D data from depth-sensing cameras which are now being embedded in higher end mobile devices may further feed the accuracy of its body tracking models (Kaia Health grabs $75M on surging interest in its virtual therapies for chronic pain and COPD, n.d.). This is just an indicator that a lot can still be incorporated. Another gap is that AI-based physiotherapy consultation apps are still pretty much standalone. In February Kaia kicked off a major integration of its patient-facing MSK therapy/pain-management app with a referral system that plugs into services offered by other healthcare providers — using an escalation algorithm and screening and triage system, which it calls Kaia Gateway — to identify patients at risk of needing more invasive or intense treatment than the digital therapies its app can provide. It's working with a number of premium partners for this referral path (such as within an employer or health plan's ecosystem). Its partners can provide additional medical services to relevant patients, both general and specialty care solutions, including disease management programs, PT, telemedicine, care navigation, and expert medical opinion services. Partners also get access to detailed treatment history on referred patients from Kaia, including via APIs (Kaia Health grabs $75M on surging interest in its virtual therapies for chronic pain and COPD, n.d.). Data from app should be made transferable and helpful in other medical fields.

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