Mapping Data Mining Technique and Gamification Approach for Studying Post-Stroke Rehabilitation Training: A systematic literature review

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ABSTRACT Data mining has been widely used in healthcare to provide treatment and care recommendations based on a collective prediction of individual conditions. For rehabilitation, various data mining techniques have been applied to predict and recommend suitable recovery paths and training. Also, the gamification concept was applied to rehabilitation training to motivate the patient to follow the training until the end. Researchers have conducted considerable research to investigate the validity and effectiveness of those techniques on massive patient data on specific conditions and treatment contexts. However, it is still unclear how to effectively offer customized rehabilitation training to stroke patients using gamification and data mining approaches. Thus, to understand how researchers studied them, we examined 34 peer-reviewed articles published in computer science and medical proceedings and journals between 2012 and 2022. We systematically reviewed the data mining and gamification techniques researchers had applied for post-stroke rehabilitation and related prediction models resulting from the data mining processes. As a result of the analyses, three significant contributions are identified. This article 1) identifies trends in data mining and gamification used in personalized post-stroke rehabilitation training; 2) maps trends in the study of data mining and gamification in post-stroke rehabilitation; and 3) identifies underexplored studies for future work. There is a definite need to continue developing and researching intervention strategies related to rehabilitation to address recovery problems by providing accuracy and protection of healthcare, as well as incorporating components that promote patients' motivation and engagement.

INDEX TERMS Data Mining, Gamification, Prediction Model, Recommender System, Rehabilitation

I. INTRODUCTION

The development of technological intervention has offered another opportunity to the way healthcare services is delivered. The delivery of services has been designed and put into practice in accordance with the guidelines in health and care. The rehabilitation was one of the most researched health domains in terms of gamification and serious gaming [1]. In rehabilitation field of study, it included providing post-stroke patients a rehabilitation training. Post-stroke rehabilitation training recovery is growing due to the availability of more patient registries and training-related data in recent years. Furthermore, as the population ages, the prevalence of chronic diseases has increase, the integration of technologies have the potential to address the need by improving the quality and accessibility of rehab training.

Recent research in healthcare and rehabilitation has heightened interest in identifying a solution to post-stroke rehabilitation needs and requirements for patients on the road to recovery. In this regard, data mining has been used to identify patterns and relationships in large sets of patient

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data, which can assist in creating personalized treatment plans for patients. This can lead to more effective and efficient rehab training [2]. However, only a few automated personalization and recommendation systems assist therapists in making systematic decisions (see [3], [4]).

Gamification techniques can help to increase patient motivation and engagement in their rehabilitation. By incorporating game-like elements into the rehab process, patients may be more likely to stick to their treatment plans and make progress towards their recovery goals. However, little is known about the impact of gamification on individualized post-stroke rehabilitation training and its application to recommendation systems. Integrating a data mining and gamification approach to recommending post-stroke rehabilitation training is relatively limited and was not inclusive due to data locality. Furthermore, by combining data mining and gamification techniques, healthcare providers can gain a more comprehensive understanding of patient progress and outcomes. This can help to optimize treatment plans and improve patient outcomes.

For the past decade, many intervention tools have been designed and applied for post-stroke rehabilitation, which includes robotics [5], exergames [3], gamification [6], Virtual Reality [7], and others. Each of these methods has been used in prior studies to address general post-stroke rehabilitation training or a particular post-stroke rehabilitation need. This situation has brought us to the question of how researchers studied them. Particularly on determining the best-suited tools for the training. Despite this study's high level of research interest, no systematic literature reviews on data mining and gamification techniques used in this domain have been conducted in machine learning and rehabilitation. Existing review studies (such as [8], [9], [10]) focused on various machine learning and rehabilitation research goals, topics, and effects. The review conducted in this paper can assist in understanding the relationship between the data mining and gamification techniques applied in post-stroke rehabilitation and the knowledge gained thus far. Additionally, it can also be a valuable means for re-searchers and others to better grasp the approaches under consideration.

In light of this, we conducted a thorough literature review on data mining and gamification techniques for studies of post-stroke rehabilitation in medical and computing journal and proceedings. The following research questions guide this systematic literature review study:

- RQ1: What are the current research trends in data mining and gamification that promote post-stroke rehabilitation training?
- RQ2: What are the most and least common data mining and gamification strategies used for post-stroke rehabilitation training?
- RQ3: What are the current research gaps for future investigation in this context of study?

By addressing the following research topics, we highlight the current state of the literature on data mining and gamification methods used for post-stroke rehabilitation, as well as how researchers use these methods to influence future rehabilitation and bio-informatics research. The remainder of the paper is structured as follows: related works to this context of studies are presented in section 2, and section 3 describes the methodology applied in conducting this systematic review. Section 4 presents the systematic review results and continues with a discussion of the findings. Finally, based on the results and findings, conclusion remarks and significance of the study are presented in Section 5.

II. RELATED WORK

A. DEFINING DATA MINING, GAMIFICATION AND REHABILITATION

To date, research on data mining applications for post-stroke rehabilitation is everywhere. There is no doubt that their prevalence and pervasiveness in today's healthcare have stimulated rapid growth in research interest in medical and computing in recent years. In medical informatics, research related to machine learning and rehabilitation have studied such data mining applications in healthcare and related phenomena by paying attention to prediction model [2, 11, 12], analysis pattern of data [13 - 15], decision-making [2], and health discourse [16]. To grasp the breadth of work in studying what researchers have done on using data mining for post-stroke rehabilitation, defining the scope of the data mining concept, gamification, and rehabilitation has assisted the author in better situating the range of study.

The computerization of processes for examining massive amounts of data and generating meaningful information has enabled knowledge extraction, known as data mining [17]. Data mining tools and techniques will forecast future trends, allowing corporations and organizations to be more proactive in making better knowledge-based decisions. Data mining techniques can now be used to rapidly find answers to health-related issues that were previously too time-consuming to answer [17]. Meanwhile, gamification is a method of incorporating game elements into non-gaming contexts [18]. Gamification in healthcare is anticipated to be able to motivate individuals to participate in the treatment and continue improving health towards self-management readiness [1, 18]. Rehabilitation, generally, is a process that a health professional devises to assist individuals in recovering from a specific health condition [18]. According to World Health Organization [19], Rehabilitation is defined as "a set of interventions de-signed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment". The health condition may also include post-stroke conditions, which can result from medical treatment, injury, or illness and can be physical, cognitive, or mental in nature [20]. Apparently, the purpose of rehabilitation