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Technological Innovations for Mental Health: A Comprehensive Literature Review

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Abstract
The field of mental health needs more human and financial resources. In order to cope with the significant increase in demands, scientists are obliged to turn to technological tools that can solve, at least in part, this imbalance. They are urgently required to seek effective and efficient solutions to alleviate and meet the problem of increased demand for the treatment and screening of mental illness. This article highlights mental illness screening and diagnosis using new technological tools such as Serious Games. This work shows the importance and effectiveness of Serious Games already used in the therapeutic treatment of mental illness. This state-of-the-art study showed that using technology to diagnose mental illness is rare, and Serious games in this field are nonexistent. This article presents the most used Serious games that have revealed their effectiveness in helping patients to treat certain psychiatric illnesses. This review aims to draw the attention of researchers to this subject by making them aware of new developments and proposing research perspectives that will help to alleviate or orient the doctor's diagnosis or orient the patient toward his or her treatment needs.
Keywords: mental illness, technology, Serious Game, screening, diagnosing.

1. Introduction

To introduce the subject, we first define the difference between the two keywords: screening and therapy.
Screening is a proactive approach employed to identify previously undetected conditions or risk indicators. It involves conducting tests or examinations to identify the most distinctive signs of a disorder that may necessitate additional investigation [1]. On the other hand, therapy is the synonym of care, treatment, and intervention. It is the attempted remediation that always follows a medical diagnosis. Indeed, there is a big difference between the two concepts.
E-health is an emerging and rapidly advancing domain encompassing research and practical applications that leverage digital technologies. Digital interventions, also known as E-interventions, are increasingly deployed in healthcare, offering potentially more accessible alternatives. These interventions come in various formats, including text-based programs, multimedia, interactive biofeedback programs, virtual reality, and serious games. E-health programs offer several advantages, including the seamless integration of intervention fidelity, the flexibility for patients to access treatment at their convenience, and the ability to progress at their own pace in the privacy of their own space [2].

2. Objectif

The primary aim of this study is to have a clear idea/plan to create a Serious game for screening a mental disease. This game will be based on machine learning to realize a digital platform allowing automatic scoring and simplified presentation of results. This approach offers the opportunity to go beyond the basic calculation of scores and use advanced algorithms. In the literature, only some studies have focused on screening, for example, Early Detect [3], while Serious games with a therapy focus appear in several studies. Early diagnosis encourages treatment in the event of mental illness, and the results can help determine the appropriate treatment. In addition, it will reduce the cost and time of treatment and increase the likelihood of recovery, which can maintain a good quality of life.
Early diagnosis of mental health decline signs can help prevent other physical health problems caused by a mental disorder. The person will know how to cope with stressful situations in life and still be able to live productively. Moreover, that will reduce the cost of treatment, increase the probability of healing and reduce the treatment time. In addition to that, it will maintain a good quality of life. The person will not be at risk of hurting themselves or others.

3. The Machine Learning at the Medical Service

A. Definition:

Machine learning (ML) is a specific branch of artificial intelligence that derives knowledge from training data [4]. ML employs advanced statistical and probabilistic techniques to build systems capable of autonomously learning from data. This facilitates the enhanced and accurate identification of patterns within data and the generation of precise predictions based on data sources[5]. The researchers grouped ML algorithms into:

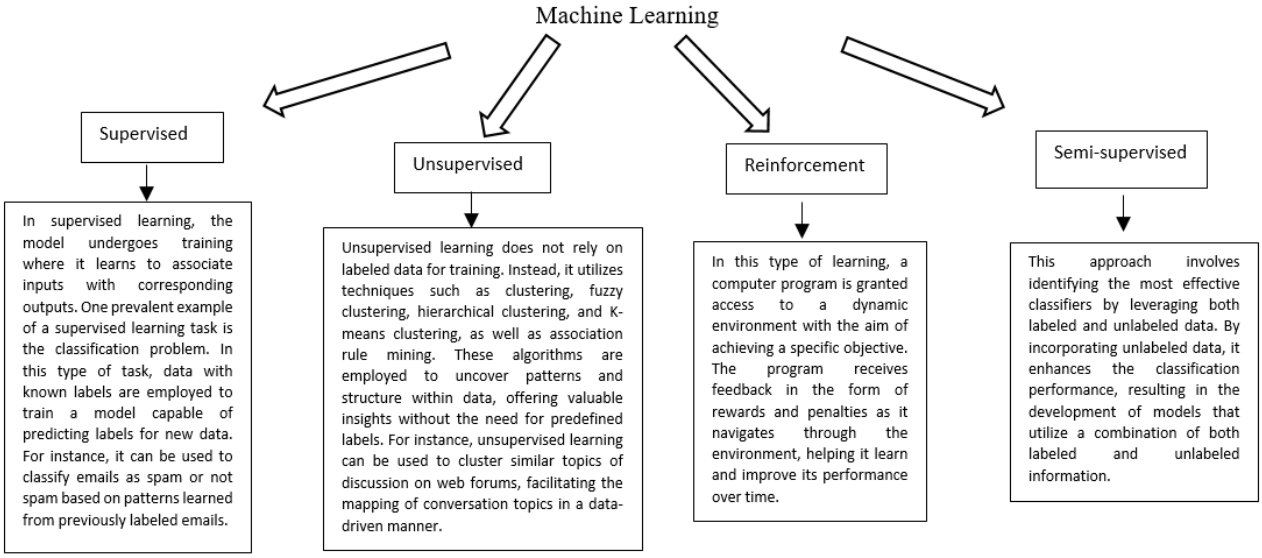

Figure 1 : Machine learning algorithms types [4] [5] [6] [7].

Moreover, due to some deficiencies in the Health Care System, the Health Information Technology (IT) Framework [8] has recommended several strategies. These strategies include fostering collaboration, understanding the preferences of consumers regarding clinicians and healthcare organizations, and promoting the adoption of IT [4].

Machine learning, when employed as a Decision Support System, plays a crucial role in disease investigation. It aids healthcare professionals by providing insights into health-related issues and by presenting relevant background information about individual patients. Additionally, it contributes to the identification and understanding of a patient's medical condition [4]. In the realm of medical applications, machine learning algorithms are instrumental in making informed decisions about treatment plans for patients, offering valuable recommendations for the implementation of an appropriate healthcare system [9].

Furthermore, there is a growing body of literature that focuses on the use of machine learning in mental health within the fields of medical and clinical psychology. This emerging research assesses the accuracy, reliability, and effectiveness of algorithms [10] [11]. It also delves into the opportunities and challenges associated with the adoption of machine learning techniques in clinical practice [12] [13].

B. Examples:

Over the past few years, numerous research initiatives have been dedicated to applying machine learning within the healthcare sector, with the overarching goal of enhancing the well-being of patients worldwide:

The Shah Lab:

Dr. Nigam Shah leads this initiative, which is part of the Center of Biomedical Informatics Research at Stanford. The Shah Lab focuses on leveraging machine learning and data mining techniques within medical ontologies to advance the concept of a "learning health system." They primarily work with Electronic Health Records that contain comprehensive longitudinal patient care data, with a significant emphasis on analyzing unstructured data.

The lab's primary objectives include addressing clinical inquiries, generating data-driven insights, and constructing predictive models related to disease progression, treatment efficacy, and healthcare processes. The goal of the Shah Lab is to provide healthcare professionals with enhanced decision-making support, enabling them to make more informed choices [14].

Lumiata:
This healthcare startup, led by Dr. Igor Barani, specializes in graph analytics and has gained recognition. MIT Technology Review has honored it by listing it among the top 50 most innovative companies of 2016 [15].

The company Berg and Interrogative Biology:
It aims to revolutionize the field of medicine by applying machine learning and artificial intelligence to medical research, ultimately leading to the development of personalized treatments for individual patients [16]. This innovative approach, referred to as the "BERG Interrogative Biology platform" [4], involves the collection of extensive data points from a patient's biology and clinical history [17]. This wealth of information serves to create a comprehensive profile of the biological processes within the patient's body [16].
For instance, consider a cancer patient preparing to undergo treatment. By utilizing the Berg Interrogative platform, specific drugs that may pose toxicity risks can be identified based on the patient's unique metabolism, biological composition, and other pertinent information. This process holds significant potential for tailoring treatments to individual patients and ensuring their effectiveness [16].
We will cite some examples of applications or organisms using AI that have been useful in medicine:

- Exa Health:

This is a mobile app for COVID-19 testing that harnesses the power of AI. The app offers fast diagnostic tests, facilitates the collection of rapid antigen tests, and provides test results directly on the user's smartphone [18].

- Babylon Health:

is a digital healthcare application that allows users to connect with a doctor or general practitioner within minutes. Users can receive medical advice through video consultations, phone calls, or text messages [18].

- Datavant:

is committed to expediting the discovery, development, and commercialization of new medicines through the utilization of machine learning. Their goal is to collaborate with biomedical research institutions to break down information silos and unlock valuable insights from healthcare data [18].

A. Results and achievements:

4. THE ML at the Service of Psychiatry

Digital technologies can be crucial in improving access to treatment and outcomes. So mental health services become more effective.
Detecting a mental disease in the medical domain is not the most challenging question but the differential diagnoses and identifying optimal treatments [12]. For this reason, machine learning approaches like multi-class prediction or multi-task learning may be well-suited for exploring variations among mental illness subcategories or treatment groups. These techniques can also assist in identifying uncharted dimensions of mental illness and align with contemporary clinical efforts to complement discrete definitions with a more continuous, dimensional symptom framework [19].
Through the amalgamation of data, we can discern four domains of applications in the field of mental health:
- Detection and diagnosis
- Prognosis, treatment, and support
- Public health applications
- Research and clinical administration [18].

Machine learning harnesses advanced statistical methods and computer science techniques to analyze extensive datasets [20]. The prevalent types of machine learning techniques utilized in psychiatry encompass supervised and unsupervised learning [21]. In psychiatry, most studies leveraging machine learning have concentrated on classification or diagnosis [22, 23]. Supervised Machine Learning processes data with a labeled response variable to construct a model capable of predicting future outcomes solely from input features [24]. It finds application in classification or predictive modeling and can account for intricate relationships between variables that may have remained undiscovered [25]. Logistic Regression ranks among the most widely used supervised learning tools in biomedical studies [26]. On the other hand, Unsupervised Machine Learning is applied to data without a labeled outcome [27]. It identifies similarities and dissimilarities among subjects using variables without predefined labels, with k-means clustering being the most used method [10].

Table 1: Results and achievements

Authors	Results	Reference
Lee and al.	They have created a linear regression model designed to predict suicide attempts among adolescents by considering sociodemographic factors, risk behaviors, and psychological variables.	[24]
Fuente-Tomas and al.	They have introduced a user-friendly, cluster-based severity classification system for bipolar disorder (BD), which has the potential to assist healthcare professionals in tailoring treatment and facilitating collaborative decision-making.	[28]
Mindstrong	They employ AI and mobile technology for the diagnosis and treatment of neuropsychiatric disorders. Their platform continuously generates digital biomarkers related to mood and cognition, including metrics for processing speed, attention, memory, and executive function. For detection and diagnosis, they utilize Supervised machine learning techniques to achieve the following objectives: - Predicting susceptibility to depression. - Distinguishing Alzheimer's disease from typical aging. - Analyzing social media data to identify signs of depressive symptoms. - Utilizing speech data to detect underlying mental states indicative of schizophrenia and depression. - Assessing the impact of medications on mental states. - Employing machine learning for distinguishing between autism spectrum disorders and epilepsy based on EEG data. For prognosis, treatment, and support, they employ the following methods: - Implementing natural language processing techniques along with supervised machine learning to predict suicidal ideation and psychiatric symptoms among recently discharged patients, leading to accurate results that could enhance prognosis. - Employing unsupervised machine learning in the analysis of social media and online communities to identify individual and psycholinguistic features most predictive of successful alcohol abstinence. - Utilizing machine learning in conjunction with smart meter data and neural networks to detect alterations in sleep behavior indicative of depression or Alzheimer's disease. - Analyzing data from wearable sensors (such as heart rate, galvanic skin response, and temperature) and applying supervised and unsupervised machine learning methods to predict stress.	[29] [30] [31] [32] [33] [34] [35] [36] [37] [38]

5. Serious Games

A. Definition:

Serious or applied games typically find their home on video platforms with a primary objective beyond mere entertainment [39]. These games simultaneously educate, train, or influence behavior while providing enjoyment to the players [40], and they have found applications in various healthcare contexts. They may offer a fresh and accessible alternative for numerous patients within mental health services [41, 42].

Types of Serious Games:

- Advergames (games used in advertising);
- Exergames (games offering physical or cognitive training);
- New games (games aimed at informing);
- Political games (games with a political leaning);
- Social games (games available on social networks);
- Business games (management simulation games);
- Games (educational games);
- Healthcare games (healthcare games) [43].

B. Examples in psychiatry:

These days, it exists a lot of validated Serious games, but just for therapy, we will try to introduce more of those games by this table:

Table 2 : Examples of games in psychiatry

Disease	Serious game	Category	Description
Anxiety	MINDLIGHT	Children, aged 7–13 years	It's a biofeedback game [44] that takes the form of a goal-driven and puzzle-solving serious game [45]. This game is presented in three dimensions from a third-person perspective, focusing on a young character's efforts to protect their grandmother from malevolent forces within her ominous mansion through neurofeedback. The game makes use of numerous approaches supported by evidence, such as neurofeedback [46], exposure training [47], and attention bias modification [48].
	ADVENTURES ABOARD THE S.S.GRIN	Children, aged 7–11 years	The game was developed by applying methods from a face-to-face, evidence-supported program for improving social skills [49]. It revolves around player interactions with non-playable characters aboard the sailing vessel S.S. GRIN, facilitated by a personalized avatar. This serious, objective-driven, and puzzle-solving game was specifically designed to cater to children experiencing challenges with their social skills [45].
	DOJO	Youth, 14.38 years	The Dojo is a game focused on teaching young individuals how to control their physiological and emotional responses, aiding in emotion management. It serves as an enjoyable and immersive resource intended to assist at-risk youth in acquiring the skills to handle their adverse emotions. Overall, the Dojo is an innovative and effective tool for helping high-risk youth manage their emotions and improve their well-being [50]
ADHD	PLAN-IT COMMANDE	8-12 YEARS	“Plan-It Commander” is an internet-based game designed to improve time management, planning, and collaboration abilities in children diagnosed with ADHD. It features a social community and a competitive aspect where players can earn badges and rewards. This game was developed by a team of healthcare professionals, researchers, and experts in the field of game design [45].
	RECOGNEYES	8-15 YEARS	This particular game is tailored to assist children with ADHD in honing their focus. It falls under the category of Serious games for cognitive training, featuring six subgames. In these games, players employ eye-tracking software to collect snowflakes while evading fire hazards [45].
	EMOGALAXY	Children	It is a powerful tool for helping youngsters with ADHD to develop their skills. It is accessible on PC, tablets, and mobile (Android) [51]
	RYTHMICAL PLANET	Children 8-11 years	This 3D game for children with ADHD uses rhythm and music to enhance social skills. Players control an alien in search of spaceship fragments and learn to make beats in single-player mode. In multiplayer mode, they must cooperate and communicate to fix the spaceship. The game encourages self-expression and uses wireless drums for movement, potentially reducing stress [52].

Disease	Serious game	Category	Description
	THE SECRET TRAIL OF MOON	For children	It consists of a series of Virtual Reality (VR) exercises combined with a chess game. It used chess as a gamified "excuse" for teaching executive functions [53].
	ANTOMNYMS	For children	This game is rooted in the Dual Pathway Model of ADHD proposed by Sonuga-Barke and encourages players to manage impulsive behavior, evaluate various situations, and devise creative solutions. Players take on the role of a superhero rescuing a world on the other side of a planet, navigating different settings and mini games to defeat attackers. Winning the game requires deliberate action and careful reflection [54].
Depression	EVO	For children	EVO is a Serious game that can be played on an iPad or other mobile devices, requiring users to guide a character through an immersive environment and respond to specific targets. The focus of EVO lies in promoting goal-setting and problem-solving [45].
	REHACOM	Adults (31-65 years)	It belongs to the range of adult neurocognitive rehabilitation therapy games. "RehaCom" is described as a serious game for cognitive training [45].
	THINK, FEEL,DO	Adults	Learning behaviors and attitudes that produce beneficial results is the goal. Beyond the different vignettes, an overarching theme is not conveyed [55].
	THE JOURNEY	Adults	The Journey recounts an adventure through mythical places, resembling a fantasy video game [55].
	REACH OUT CENTRAL	Adults	The goal is to integrate and establish oneself in a new town successfully. The user must figure out how to fit in, make friends, and get around as they are new to the area [55].
	THE JOURNEY TO THE WILD DIVINE AND FREEZE-FRAMER	Adults	The goal is to finish the numerous chores and endure increasingly tricky stages. Action with other characters' Journey to the Wild Divine has users enter a fantasy world and undertake a journey [55].
Schizophrenia	I LFE	Adults	The player had to accurately identify each emotion displayed on several photographs of people's faces. It is classified as a cognitive training Serious game [45].
	VOICES	Adults	The objective of the game is to practice emotions. It is described as a cognitive training Serious game [45].
	OCEAN EMPIRE	Adults	An exergame that promotes physical activity and includes a puzzle game. Players catch creatures with strategy and can purchase upgrades in the shop. It is a mobile game that rewards players for completing planned physical activities and sends reminders to help them stay consistent [56, 57].
Alcohol dependence	JIB	Adults	An Android mobile game simulates the adverse effects of alcohol addiction on the protagonist in a forested environment. The game increases speed and fun to show the effects of alcohol abuse and the possibility of premature death [58]

Disease	Serious game	Category	Description
Bipolar disorder	BIPOLE	Adults	The player must control the mood of an avatar with bipolar disorder in real-world scenarios. It is a serious game that emphasizes goal-setting and problem-solving [45].

C. Other therapy tools:

In addition to those games, there are other ways for different diseases like “CURAPY”, a platform that contains different serious games for some diseases like Alzheimer and Parkinson.

6. Serious Games as Screening Tools

Nowadays, there are a few tools for screening a mental disease. In this part, we present the most useful, which are The "Speech" and the "EarlyDetect" tools. "EarlyDetect" is a self-report screening tool to detect common psychiatric diseases. It consists of clinical self-report questionnaires condensed to resemble clinical interviews (LHQ, MINI-HME, and MDQ) [59]. To assess and compare screening performance, the researchers adopted a machine learning approach that was adapted from a previous study that concentrated on screening for Major Depressive Disorder (MDD) [3]. The machine learning analyses were conducted using Python 3.6 with Scikit-Learn 0.22.1. The model's input features included individual questions from clinical questionnaires, which encompassed binary yes/no responses to questions from the Mini International Neuropsychiatric Interview (MINI) screening tool, as well as age and gender. Questions pertaining to age and those using Likert scales were treated as continuous variables and were standardized using the Standard Scaler function, whereas questions with binary yes/no responses were encoded as dummy variables without further rescaling [59].

The development of self-report tools for digital platforms is on the rise and has already been widely utilized to aid in the diagnosis of bipolar disorder within clinical settings. The EarlyDetect tool specializes in screenings for ADHD, alcohol use disorder, major depression, and generalized anxiety [59].

One of the key advantages of employing a digital platform as a self-report screening tool is the ability to automatically score and present results in a streamlined manner. This opens opportunities to go beyond basic score calculations and harness advanced algorithms like machine learning. A critical advantage of machine learning lies in its use of cross-validation techniques, where data is divided into smaller subsets, and models are systematically developed on one subset while the remaining data, kept "blind" to the computer, is reserved for evaluating the predictive validity of the learned model [59].

Another notable development is the "Speech" technology, which utilizes machine learning on speech samples obtained either in a clinical environment or remotely. This technology holds the potential to serve as a biomarker that could enhance the diagnosis and treatment of conditions like MDD, bipolar disorder, and schizophrenia. The studies conducted over the past decade have employed speech to identify the presence or severity of disorders outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). These studies provide detailed descriptions of sample sizes, clinical evaluation methods, speech-eliciting tasks, machine learning methodologies, performance metrics, and other pertinent findings [60].

7. Discussion

Diagnosing is always a critical field that requires precision. The primary tool used is the classical tests (g pen-and-paper screening tests). However, this last one has some relevant limitations, such as being perceived as intrusive [61], being influenced by the white-coat effect [62], providing a late diagnosis [63], lacking ecological validity [64], being strongly dependent on confounding factors (e.g., age, educational level) [65], practice effect [66, 67], or being prone to processing errors due to their manual processing [24], and being biased by culture, gender, and educational level and having long test–rest periods (usually one month or more) [68].

Due to the need for a powerful and alternate method that replaces the diagnosis those classical tests and supports an early diagnosis of cognitive impairment [69], the scientific literature discusses several approaches such as the digitalization of classical tests [70], the introduction of game inspired design approaches (e.g., rewards, challenges, simulated environments) [71], and the implementation of the machine learning. So, by using gamification techniques and machine learning, we finally create a weapon that can quickly realize the precision and validity of diagnosing. As an example, we mention:

Episodic: is a video game designed to evaluate episodic memory by gamifying the California Verbal Learning

Test (CVLT) [69]. It serves as a valuable tool for distinguishing between individuals with mild cognitive impairment (MCI), Alzheimer's disease (AD), and healthy individuals (HC) [69].

Smartkuber: a Cognitive screening serious game of elderly [68].

A. Strengths and limitations:

As with any tool, the relationship between Serious game and machine learning has some strengths and limitation:

Table 3 : Strengths and limitations :

Strengths	limitation
These advantages of cognitive assessment tools are: - it motivates and engage the user [68]. - They are cost-effective in terms of time and money. - it is self-administered or require minimal training. - it offers an enjoyable user experience. - it provides precise and frequent response recording devoid of the biases and effects associated with traditional methods. - it alleviates the psychological stress associated with conventional screening processes [72, 73] - it can be validated against established tests commonly used in clinical practice. - it offers constant monitoring of the player's cognitive health in an enjoyable, motivating, and engaging manner [72]. -it manages unpredicted behaviors, different player profiles, and interpretations [74, 75]. - Applying many ML algorithms to have the best prediction result.	- Sometimes the study uses a small sample size. - The researchers use a small dataset for training the ML. - Complexity of developing, using, or understanding a Serious game. - The cost to develop or maintain is expensive. - Lack of creativity. - It depends on data provided. - The time of developing is long and the changes are a lot.

8. Conclusion

Intelligent solutions and inventions have a significant impact on our lives because it helps us to automate processes, reduce costs, and improve efficiency. For therapy and Mental diseases, those solutions can be an excellent way for a patient to understand their emotions and for the doctors to know the root cause of their issues and give more strategies. Additionally, many therapists are now incorporating technology into their practice, such as serious games that use VR or AI. Serious games have shown their effectiveness and usefulness at the level of therapy and introducing them into the medical field has been an appropriate decision. Indeed, the doctor and the patient can appropriate unusual means for decision support, orientation, or treatment. Unfortunately, screening for a mental illness has not aroused the same interest among researchers despite its importance in referring the patient to early detection and effective treatment. The question that arises and opens up new research perspectives is whether serious games could contribute to detecting mental disease and lightening and making treatment more effective.

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