Leveraging Artificial Intelligence and Robotics to Improve Mental Health

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Abstract

Artificial Intelligence (AI) is one of the oldest fields of computer science used in building structures that look like human beings in terms of thinking, learning, solving problems, and decision making (Jovanovic et al., 2021). AI technologies and techniques have been in application in various aspects to aid in solving problems and performing tasks more reliably, efficiently, and effectively than what would happen without their use. These technologies have also been reshaping the health sector's field, particularly digital tools and medical robotics (Dantas & Nogaroli, 2021). The new reality has been feasible since there has been exponential growth in the patient health data collected globally.

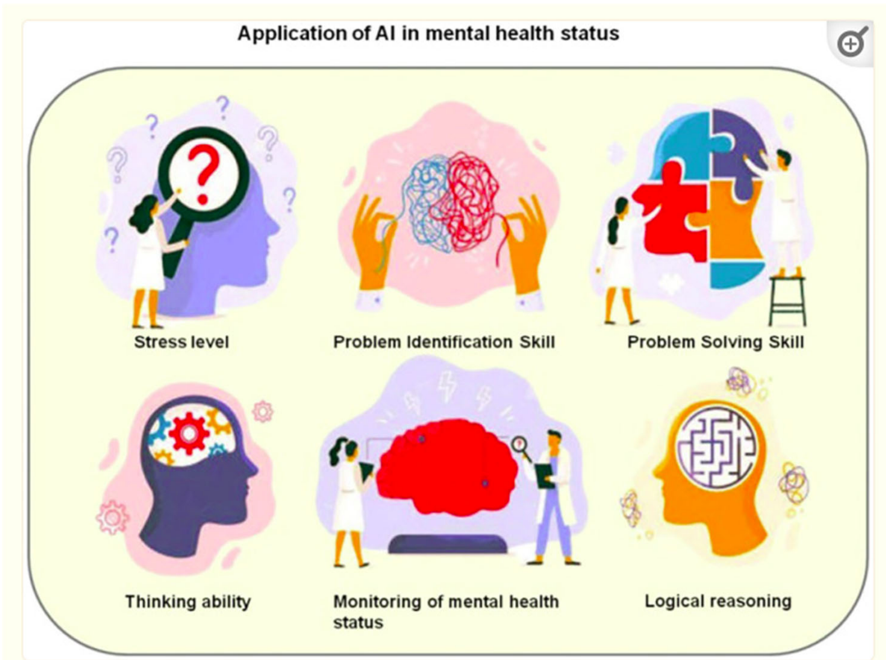
The different technological approaches are revolutionizing medical sciences into data-intensive sciences (Dantas & Nogaroli, 2021). Notably, with digitizing medical records supported the increasing cloud storage, the health sector created a vast and potentially immeasurable volume of biomedical data necessary for implementing robotics and AI.

Despite the notable use of AI in healthcare sectors such as dermatology and radiology, its use in psychological healthcare has neem models. Considering the increased mortality and morbidity levels among patients with psychiatric illnesses and the debilitating shortage of psychological healthcare workers, there is a vital requirement for AI and robotics to help in identifying high-risk persons and providing measures that avert and treat mental disorders (Lee et al., 2021).

This discussion is focused on understanding how AI and robotics could be employed in improving mental health in the human community. The continued success of this technology in other healthcare fields demonstrates that it could also be used in redefining mental sicknesses objectively, identifying them at a prodromal phase, personalizing the treatments, and empowering patients in their care programs.

Related Work

According to Liu (2022), there is an evident use of AI technology and methods in the community that human beings no longer respect as AI-based. In the mental health field, there are AI-based monetary solutions that range from smartphone applications to wearable gadgets that enhance and could even replace the function of a psychologist in case the technology is advanced further (Liu et al., 2022). These solutions show that AI could make decisions, evaluate, and treat patients. The figure below demonstrates how AI could be applied to mental healthcare.



Other researchers would explain the effect of integrating AI in the working environment to deal with employees' mental health, specifically from the standpoint of labor-capital relationships. Wei & Li (2022) conducted a survey using statistics from the 2018 China Labor Force Dynamics Survey to assess the effect of AI on the depressing indicators of workers within the manufacturing sector.

Their research found that AI could reduce psychological depression levels by scores of 1.643 points which shows the technology supports the workers' mental wellbeing (Wei & Li, 2022). This effect would, however, vary by proficiency level and generation.

AI advances the psychological health of low-skilled industrial workers by 2.342 points, while those born before 1980 improved their mental health by 2.070. The findings from this research showed that applying AI in the working environment could improve the mental health of manufacturing workers.

This study showed that AI technologies do not intend to replace humans and destroy the economy and society. Instead, their use mainly makes human beings more efficient and productive. Ultimately, Oakman et al. (2020) noted that AI technologies would help workers manage their emotions, especially those that arise in an overwhelmed working environment, subsequently improving their mental health.

How could AI and Robotics possibly improve mental health?

The current AI systems could be used to reinforce the capacity to distinguish between the same primary clinical presentations but with different treatment methods. An example is recognizing bipolar as against unipolar depression depending on the brain imaging aspects or determining the differential dementia types using structural MRI scans. Additionally, the data-driven approach could aid in identifying the novel disease subtypes by considering the heterogeneity of presentations, demographic features, and environmental elements (Liu et al., 2020).

The third technique is having the AI approaches to build models from novel data sources and synthesize them from heterogeneous data streams such as EHR and behavioral information from the wearable sensors' social media feeds, among others. The aim is to merge the descriptive and automatic models of mental illness across the self-report sources to the molecular evaluations. The diagrams, including the social media photographs and reports from the scans, could predict one's risk of developing a mental health disorder.

The figure below shows three primary AI-based techniques for observing the brain while studying psychiatric disorders: magnetic resonance imaging (MRI), electroencephalography (EEG), and kinesics diagnosis.

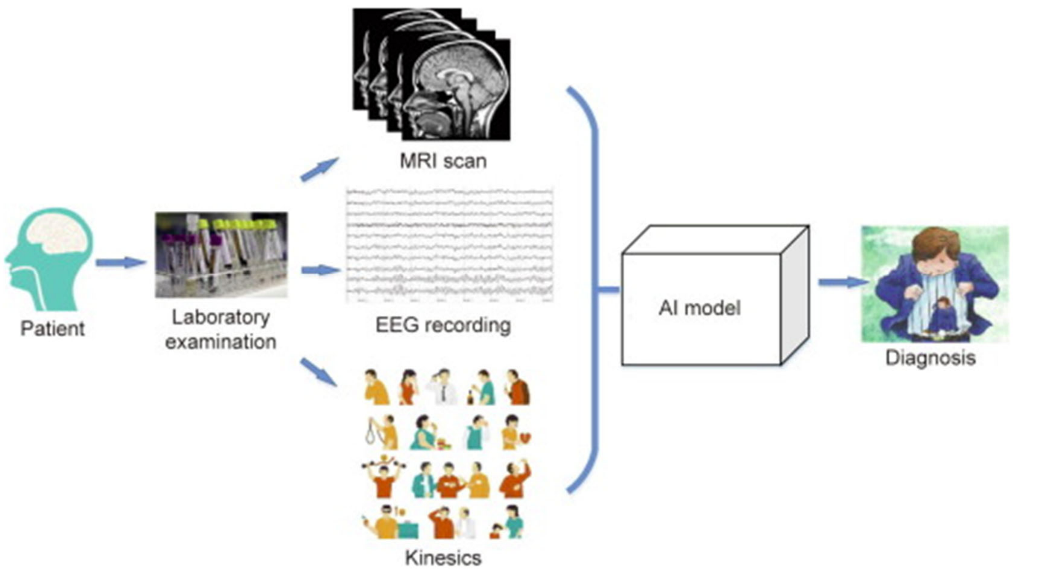


Figure 2: Observation Techniques for Psychiatric Disorders

MRI has been the predominant technique for behavioral and cognitive neuroscience as it allows the exploration of common psychiatric abnormalities which cannot be detected by computed tomography (Liu et al., 2020). Currently, the commonly used AI techniques such as multimodal learning and deep learning techniques used in brain imaging could also be used in the practical analysis of disease information to identify the key biomarkers and increase the capacity to treat brain diseases.

Electroencephalography (EEG) is another essential AI-based technology that could diagnose and treat the human brain's nervous system disorders (Liu et al., 2020). Mainly, the technology allows the detection and recording of human EEG signals necessary to understand the processes of the human brain and diagnose psychiatric conditions. EEG has demonstrated a higher temporal resolution than MRI and CI hence essential in research and diagnostics in the studies focused on assessing anxiety, depression, and psychosis. Therefore, applying the classical machine learning algorithms to process EEG information is crucial in classifying patients with mental health disorders.

A study by Iosifescu et al. (2009) implemented the support vector machine for processing the resting-state EEG information for 88 topics and attained a 70% classification accuracy. Additionally, Bisch et al. (2016) incorporated logistic regression (LR) in classifying a nine-lead EEG for depression to achieve an 83.3% classification accuracy.

Finally, the kinesics data that looks into behavioral and facial information is also crucial in studying pathogenesis, development transitions, and assistance in diagnosing psychiatric disorders AI-based techniques have been very critical in analyzing this information, hence abetting the diagnosis and prediction of psychiatric disorders (Liu et al., 2020).

In conjunction with extensive research, these three AI-based technologies and methods would prove that Artificial intelligence (AI)-based applications are becoming fundamental in psychiatric examination and diagnosis. The ability to provide the diagnostic results fast using the techniques will ensure that the patients can start their recovery treatments and improve their mental health considerably.

Mental health professionals have noted that there has been an increase in the demand for mental health care as many patients are seeking therapy, among others. According to Figure 3, it is evident that the care providers are dealing with an increase in the number of patients with all the different disorders. Notably, AU-based technologies could come in handy to help with the increasing workload.

Bateman et al. (2021) noted that the technologies could first be used to monitor quality control among therapists, especially when their workload is overwhelming. For instance, the language used during therapy interactions could be analyzed through natural-language processing (NLP). This technique entails machines processing transcripts which will provide therapists with better insights into their work and ensure that they deliver high standards of care and make consistent improvements.

AI technologies also come in handy when therapists have to sift through extensive data to identify any history, behavior, and responses to other treatments. This ensures they make accurate diagnoses and better insightful decisions in the therapy and therapist's selection.

AI will also be fundamental in justifying treatments such as Cognitive Behavioral Therapy (CBT). CBT is focused on identifying negative thought patterns and finding ways to break them. Through AI, the therapist will discern patterns during the CBT sessions, identify the problem and hasten the patient's recovery rates.

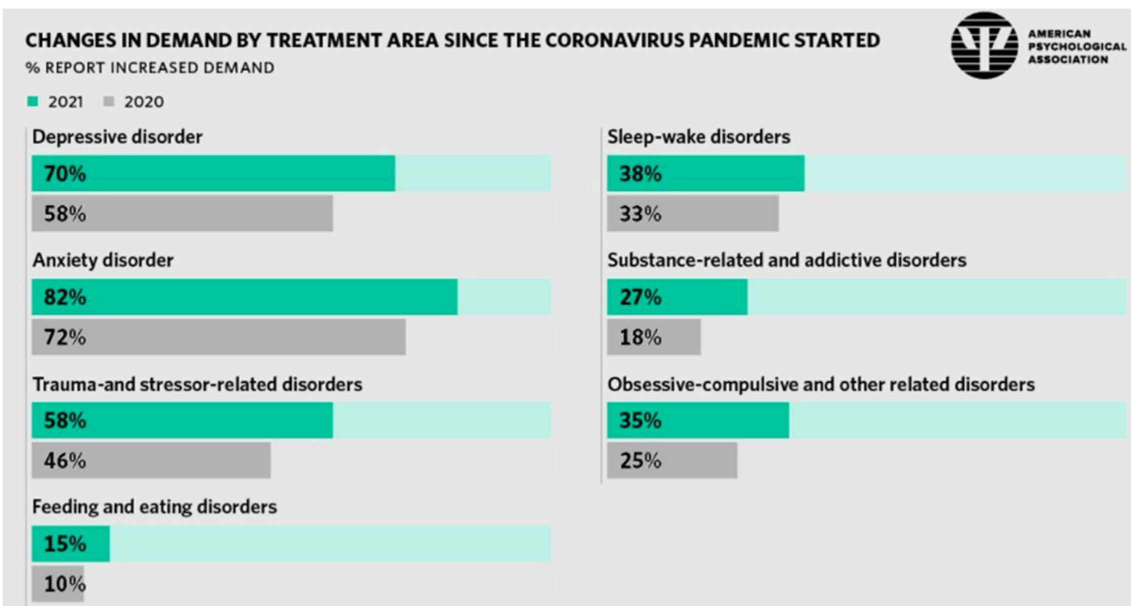


Figure 3: Changes in Demand for Mental Health Care after the Coronavirus

Considering the impact of robotics in improving mental health, Socially Assistive Robots (SARs) have been playing a fundamental role in supporting patients with dementia, among other mental health issues. SARs are primarily robotic technology platforms with audio, visual, and movement capabilities (Riek, 2016). They aim to create friendly and effective interactions with a human user with a further target of providing assistance to the user and attaining measurable progress.

Before the COVID-19 pandemic in 2020, several tools, including simple voice interfaces to the interactive social robots, were used to provide stimulation, entertainment, personal assistance, monitoring, and safety to elderly persons and people with disabilities. Notably, the recent past would show that social robots could aid in handling emotions such as irritability, neuropsychiatric symptoms, and other emotional responses.

SARs are now in themselves interventions and also platforms for interventions. This means they can learn and engage socially with persons while providing user interventions, such as patient health tracking applications and skills training applications for professionals. They could engage users across several sensory options, creating several modalities to deliver content in the interactions.

However, it is prudent to note that the use of SARs in managing mental health issues is still in its nascent stages; hence providers are advised to take caution when using autonomous robots to provide direct therapy to patients dealing with mental health disorders (Riek, 2016).

Nevertheless, with the fast development of computer processors and storage and new advancements emerging in machine learning and multimodal processing, a world is full of possibilities, including robots being capable and agile in human social environments.

The Development of a Multimodal Robotic System

The multimodal robotic framework will integrate verbal/contextual speech with nonverbal social cues to better engage in human-robot interaction and facilitate mental health telemedicine (Lima et al., 2021). This system will have an affective hybrid face robot that integrates a digital face that could show facial expressions and a 3D printed face needed to demonstrate realism and depth, which could flexibly be added to the robot.

The face comprises four facial features: eyebrows, eyelids, eyes, and lips, which have 13 Degrees of Freedom (DoF) (Lima et al., 2021). The realistic features, including the constant motion of either of the features, ate controllably and could lead to more dynamic human-robot interaction.

The figure below shows the 13 degrees of freedom of the expressive face considering the different facial features.

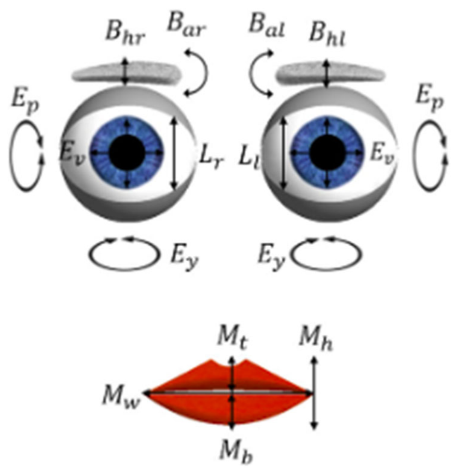


Figure 4: Thirteen Degrees for the Facial Expressions

It is also prudent to note that the robot's software design depends on mathematical methods to map emotions. The approach would allow manually or remotely controlled modeling of emotions through selecting every expression's intensity. The formula is:

$$\vec{e} = \sum_{i=1}^{n} \left(\vec{b}_i - \vec{b}_N \right) \vec{w}_i + \vec{b}_N$$

Note that:

- The robot's expression state, e→(t), for any given time, t, refers to the weighted linear combination of a set of basis expressions B = {b→1, b→2,…,b→n}.
- Each vector contains 13 values representing a degree of freedom of the digital face.

- The intensity vector w→=[w1, w2,…,wn]T, wi∈[0,1] represents the extent to which the amount by which an expression b→i contributes to e⇀(t).
- Therefore, any expression state represents the weighted sum of variances for every basis expression, b→i, from the neutral expression, b→N. It is then added to the neutral expression along the above equation.

Conclusion

AI technologies and robotics are there to revolutionize any individual's mental health, regardless of their position. Considering the health sector, whose aim is improving the health levels of its patients, the use of any technology remains fundamental. In this case, AI technologies and techniques provide both ways and machines that could help analyze patient data, diagnose their disorder, and put them in the proper treatment plans.

The professionals benefit considerably from these techniques since the latter will handle the redundant activities to provide accurate results. In contrast, professionals focus on helping their patients get the proper treatment.

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