Expert Systems
Diagnosis and Treatment of Anxiety

Hugo Pereira [1222686], Leonardo João [1222742], Mariana Ribeiro [1222746], Miguel Silva [1201045]

[1] Instituto Superior de Engenharia do Porto, ISEP, Politécnico do Porto
[2] Rua Dr. António Bernardino de Almeida 431, 4249-015, Porto, Portugal

Abstract. In this article, we explore various factors related to anxiety, examining its multifaceted nature. We address the causes, symptoms, and impacts of anxiety, emphasizing the importance of understanding the biological, psychological, and environmental underpinnings of this disorder.

Furthermore, we investigate the role of expert systems in the diagnosis of anxiety. We demonstrate how these systems, utilizing advanced artificial intelligence techniques and data processing, have the potential to enhance the accuracy and efficiency of diagnoses. We discuss their advantages in terms of accessing a vast amount of clinical data and their use in the analysis of subjective information, as well as the identification of patterns that may go unnoticed by clinicians.

This study provides a comprehensive overview of the current state of knowledge about anxiety and highlights the importance of expert systems in the field of mental health. Understanding the factors contributing to anxiety and adopting new diagnostic tools can promote more effective interventions and better treatment for individuals suffering from this disorder.

Keywords: Anxiety, Diagnosis, Mental Health, Artificial intelligence, Expert Systems.

1 Research Background

The significant advancement of artificial intelligence in various fields is evident and the field of medicine is no exception. The goal of AI applied to this field essentially involves the analysis and processing of medical data, leading to a range of benefits, with decision support being one of them.

Anxiety is a branch of the field of psychiatry, and it can be defined as a normal human emotion. However, it becomes a problem if it persists in certain contexts, affecting day-to-day functioning, causing physical and/or emotional suffering and can be defined as an anxiety disorder. It has become a common issue in society due to the increasing number of diagnosed cases, emphasizing the significance for specialists to seek ways to alleviate this situation.

As a result, our goal is to assess, analyze, and investigate the role of artificial intelligence in mental health, specifically in anxiety. Our focus will be on the expert systems developed up to this point.

In the process of researching and gathering information for this scientific article, various sources of reference were utilized. These sources included the review of academically relevant scientific articles, which provided a solid knowledge base on the topic under study. Additionally, reputable news articles and reports were explored, offering up-to-date and pertinent information for the analysis of the subject at hand. The amalgamation of these sources allowed for a comprehensive and well-informed approach, ensuring the quality and integrity of the information presented in this article. The keywords used to find these articles were Anxiety Diagnosis, Mental Health, Artificial intelligence, Expert Systems.

1.1 Expert system

An expert system is a tool *"that uses knowledge and inference procedures to solve problems"* [1]. This knowledge is based on human knowledge, since all the knowledge necessary to fill a **knowledge base** comes from professionals in the area, experts, allowed *"the computer to approximate human judgment"* [2] allowing us to think of the system as the "*expertise of the best practitioners in that field"* [1].

The main goal of an expert system is to "enhance *the quality and availability of knowledge required by decision makers in a wide range of industries"* [2]

1.2 Anxiety

Anxiety is an intrinsic experience of the human condition and an aspect of psychology that has been studied and discussed throughout the history of humanity [3]. However, in contemporary society, anxiety has emerged as a phenomenon of growing concern and research. Often labeled as the "disease of the century," anxiety is a universal experience that, in recent decades, has gained intensity in our modern society. It knows no geographical, social, or age boundaries, affecting the entire population. [3]

Anxiety in Society. In 2019, one billion people, including 14% of the world's adolescents, were living with a mental disorder [3]. In the European Union, anxiety also represents a significant concern in mental health. Data reveals that Portugal is the fifth country in the European Union with the highest number of people suffering from anxiety and depression. These statistics emphasize the importance of understanding and addressing anxiety, as well as developing effective intervention strategies to deal with this issue[3] These numbers underscore the need to increase investment in mental health and ensure that effective and accessible services are available for all. Transforming the approach to mental health is essential, as mental health is directly linked to physical health, human rights, and socioeconomic development. Investing in mental health means investing in a healthier and more equitable future for all.

The World Health Organization (WHO) report highlights the need to accelerate the implementation of the Comprehensive Mental Health Action Plan 2013-2030 to reduce stigma, improve access to mental health care, and raise awareness about the importance of mental health worldwide. [4]

In an increasingly anxious world, understanding the complexity of anxiety is fundamental.

Methods of Diagnosing an anxiety disorder. The diagnosis of anxiety disorders is a crucial part of mental health practice. This process involves specific criteria and precise assessments to identify and understand the several types of anxiety that affect individuals.

Diagnosing anxiety disorders is a fundamental task for mental health professionals. This involves distinguishing between an anxiety disorder and anxiety considered normal in humans. For this distinction, references such as the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, 5th Edition) are used, which provides specific criteria for identifying psychological disorders [5]. The DSM-5's main goal is to establish clear and objective criteria for identifying mental disorders. It describes symptoms, diagnostic criteria, and additional information for each recognized mental disorder. This framework helps mental health professionals assess and diagnose patients based on observed and reported symptoms.

After diagnosing an anxiety disorder, the types of anxiety, as defined in the ICD-10 (International Classification of Diseases and Related Health Problems, 10th Edition), are taken into consideration [3]. The ICD-10 provides an international classification of diseases and health problems, which aids in identifying several types of anxiety and their specific characteristics.

To achieve a more precise and personalized diagnosis, it is common to use a questionnaire that addresses the characteristics of each type of anxiety. Specific questions are presented to the patient, who can assess the intensity of their responses on a scale. This questionnaire functions as a dialogue between the professional and the patient, allowing for a more accurate analysis of symptoms. An example of such a questionnaire is the SCL-90-R (Symptom Checklist-90 Revised).

It is important to emphasize that treatment is not specified during the diagnosis, as it varies in each situation and depends on various external factors. The diagnosis of anxiety disorders involves distinguishing between normal and pathological anxiety, identifying types of anxiety using references such as the DSM-5 and ICD-10, and personalized assessment through questionnaires like the SCL-90-R. Treatment is tailored to each patient and may vary based on professional evaluation.[6]

2 Anxiety-Linked Expert Systems

2.1 Expert System for Measuring Anxiety Level

Fuzzy Logic Inference is a technique that deals with uncertainty and imprecision in decision-making systems.

In this type of system, instead of using binary values, fuzzy logic employs fuzzy sets to represent variables. These sets allow for the representation of concepts defined by fuzzy boundaries, such as those that arise in natural language or qualitative concepts. A fuzzy set's membership function indicates how much a specific concept is a member

of a set. This function maps the value, which could be a member of the set, to a number between 0 and 1, where a membership degree of 0 indicates that the value does not belong to the set, and a degree of 1 signifies that the value is a complete representation of the set.[7]

A recent expert system promised to predict anxiety levels based on physical symptoms using fuzzy logic inference. [8]

The system uses fuzzy logic as an inference technique, employing five symptoms as input variables and one as an output variable, anxiety. **Figure 1** displays the input symptoms: nervousness, panic, sweating, tremors, and increased heart rate, along with the output variable, anxiety. The goal is to predict anxiety levels based on these physical symptoms.

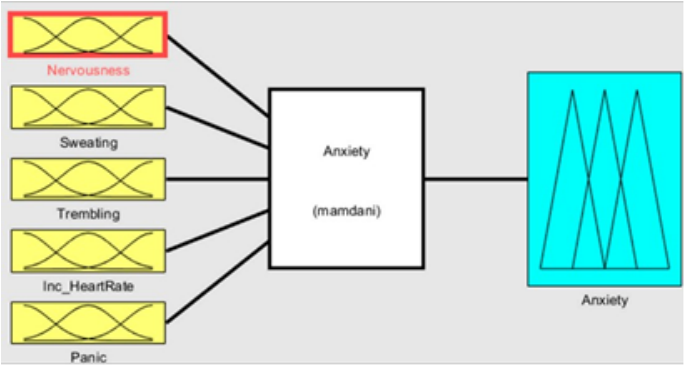

Figure 1-Input e Output from the system [8]

Instead of using binary values, the system uses fuzzy sets to represent variables. These sets enable the representation of concepts with fuzzy boundaries, without the need for exact values. The input variables, nervousness, and panic, each had three fuzzy terms (low, moderate, and high), while the remaining variables had two terms (no and yes).

Figure 2 presents a graphical representation of the membership function for the input variable, nervousness. For this variable, three fuzzy sets are considered: "low," "moderate," and "high," each with its own membership function.

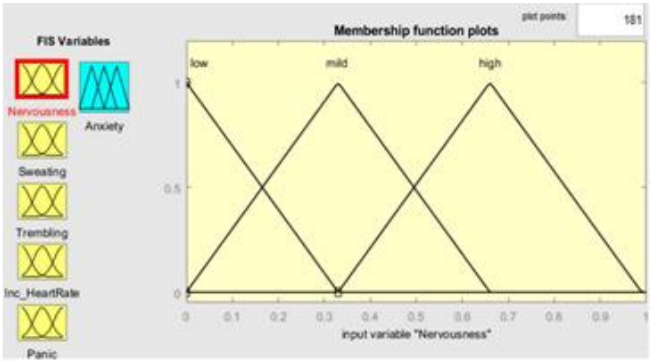

Figure 2-Representation of the membership function for the input variable "nervousness." [8]

The rules of this system were defined with the guidance of experts in the field, utilizing linguistic terms and mathematical expressions to relate all the variables. This guidance was crucial in defining rules to ensure that they were representative and accurate.

After inference, the system produces a fuzzy result for the anxiety level. To make this result usable, the “defuzzification” process is applied. In this process, the resulting degree for each output variable qualifier is converted into a fixed value. [7]

In the end, the system is evaluated for its accuracy in predicting anxiety levels. Accuracy is measured by comparing the system's predicted results to actual medical diagnoses. In the mentioned study, the system achieved an accuracy of 87%.

In conclusion, this article serves as an important reference for the system to be developed by our team. It also contributes to an understanding of how current research is exploring new techniques and approaches to address anxiety, highlighting the need for more precise and flexible systems. This contribution is significant in the way anxiety is diagnosed and treated today, indicating a trend toward more advanced, effective, and intelligent systems for combating this condition.

2.2 Expert System Based on SCL-90-R

To provide a brief explanation, the SCL-90-R (Symptom Checklist-90-Revised) is a questionnaire used to assess psychological symptoms and psychiatric disorders in patients. It was designed to assist psychiatrists in creating an initial profile. The questionnaire consists of 90 questions and covers various psychological issues, including somatization, obsessive-compulsive disorder, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoia, psychoticism, and additional issues such as sleeping problems, loss of appetite, and guilt feelings. Participants rate their own experiences on a 5-point scale. With the responses, professionals can gain an initial understanding or focus on a more specific or likely disorder.[6]

The system created was an artificial intelligence-based decision support system for diagnosing mental disorders. The study involved two main phases: data collection and

preprocessing and variable selection using the Networked Pattern Recognition (NEPAR) algorithm.[9]

The first phase involved the development of an online portal called "Psikometrist" to collect participants' responses to the SCL-90-R questionnaire. Mental health professionals could register on the portal and send an encrypted link to participants to complete the questionnaire.

This study was quite successful, with more than 6,000 participants, providing ample data to train and improve the AI.

In the second phase, the NEPAR algorithm was used to reduce the number of SCL-90-R questions from 90 to 28 while maintaining the ability to diagnose the 10 mental disorders. NEPAR was used to calculate similarities between questions and participants.

Next, AI and machine learning models were constructed using participants' responses and NEPAR measures, resulting in the introduction of the new instrument called "SCL-28-AI".

The program's outcome was highly positive. The new SCL-28-AI allowed for faster and more accurate diagnosis of mental disorders, reducing the number of questions while retaining the ability to diagnose the 10 types of disorders.

The inclusion of participant similarity measures (NEPAR-P) significantly improved the diagnostic accuracy, and the ethical and transparent approach adopted in the study set an example of the practical implementation of ethical principles in AI for mental health.

In summary, the study presents a transparent, ethical, and effective decision support system to assist various mental health professionals in diagnosing mental disorders that is simpler than the SCL-90-R it is based on.

3 Existing expert systems vs expert system to be developed

In the context of psychiatry and anxiety diagnosis, it is essential to analyze existing approaches and expert systems to better understand how the new proposed system fits. The proposed expert system's main objective is to assist psychiatric experts in diagnosing anxiety, classifying patients into three categories: those who have an anxiety disorder, those in whom anxiety is secondary to another condition and those whose anxiety symptoms are considered common part of the human condition. Based on this assessment, the system offers expert advice and treatment suggestions tailored to each patient's specific situation.

On the other hand, the expert systems that already exist in the area of psychiatry present different approaches. For example, one such system uses fuzzy logic to predict anxiety levels based on physical symptoms such as nervousness, panic, sweating, tremors, and increased heart rate. Instead of using binary values, fuzzy logic employs fuzzy sets to represent variables, allowing the representation of concepts with imprecise

boundaries, without the need for exact values. This system aims to provide predictions of anxiety levels based on physical symptoms.

Another expert system is based on the SCL-90-R (Symptom Checklist-90-Revised) Symptom Questionnaire, a 90-question tool designed to assess psychological symptoms and psychiatric disorders in patients. This system uses artificial intelligence to reduce the number of questionnaire questions from 90 to 28, while maintaining the ability to diagnose 10 types of mental disorders. This results in a more efficient and accurate approach to diagnosing mental disorders.

A notable distinction between the proposed system and existing systems lies in flexibility. The proposed system is designed to accommodate different scenarios, identifying primary and secondary disorders and anxiety as a common experience of the human condition. In contrast, existing systems generally focus on more specific goals, such as measuring anxiety levels or diagnosing mental disorders.

However, it is important to note that the accuracy of the proposed system is not mentioned in the given context, while one of the existing systems achieved an accuracy of 87% in predicting anxiety levels. Including the accuracy and effectiveness of the proposed new system would be crucial to assess its value in comparison to existing approaches in the field of psychiatry.

In summary, their proposed expert system demonstrates a flexible and comprehensive approach to anxiety diagnosis, addressing different scenarios, whereas existing expert systems generally focus on more specific objectives. However, it is critical to conduct additional evaluations to determine the accuracy and effectiveness of the proposed system relative to existing approaches in order to assess its impact on clinical psychiatry.

4 Results

In the exploration of anxiety and the role of expert systems in its diagnosis and treatment, several key findings and advancements have emerged. These findings shed light on the potential of artificial intelligence and expert systems to enhance our understanding and management of anxiety disorders. Below, we summarize the most notable results from our research:

4.1 Expert Systems for Measuring Anxiety Levels

One of the significant outcomes of our research is the development of an expert system that utilizes fuzzy logic inference to predict anxiety levels based on physical symptoms. This innovative system demonstrated a high level of accuracy, achieving an 87% success rate in predicting anxiety levels based on nervousness, panic, sweating, tremors, and increased heart rate. By embracing fuzzy logic and considering the fuzzy

boundaries of concepts, the system offered a flexible approach to diagnosing anxiety. Its potential to provide quick, accurate assessments suggests that it can be a valuable tool in clinical practice.

4.2 Expert System Based on SCL-90-R

Another noteworthy result from our investigation is the creation of an artificial intelligence-based decision support system for diagnosing mental disorders using data from the SCL-90-R questionnaire. The development of the "SCL-28-AI" instrument allowed for the reduction of questions from 90 to 28 while maintaining the ability to diagnose ten different mental disorders. By employing the Networked Pattern Recognition (NEPAR) algorithm and participant similarity measures, this system significantly improved diagnostic accuracy and efficiency. The ethical and transparent approach taken in this study serves as a practical example of incorporating ethical principles into AI for mental health.

4.3 Ethical Considerations

In the development of expert systems for anxiety diagnosis, ethical considerations play a crucial role. While these systems have the potential to enhance diagnostic accuracy and efficiency, it's essential to underscore that they should complement rather than replace human healthcare professionals. The empathy, support, and understanding provided by clinicians remain vital in the care of individuals facing anxiety. It is imperative to strike a balance between leveraging cutting-edge technology and preserving the human touch in the treatment of mental health conditions.

4.4 Future Directions

The results of this research highlight the promising contributions of expert systems in improving anxiety diagnosis. We anticipate that these findings will pave the way for future studies and the integration of traditional clinical approaches with state-of-the-art technology. The goal is to continue enhancing the quality of life for individuals struggling with anxiety disorders and advancing our understanding of this complex mental health issue.

In summary, our exploration of anxiety and expert systems has yielded valuable insights into how advanced technology can be harnessed to address and manage anxiety. This research emphasizes the need for continued research and innovation in the field of mental health, with the ultimate aim of providing more effective support and treatment for those affected by anxiety disorders.

5 Conclusion

Throughout this article, we have explored the complexity of anxiety and the increasing importance of expert systems in diagnosing this disorder. Anxiety is a condition that affects millions of people worldwide, impacting society in various ways. We understand that anxiety is influenced by a combination of factors, including genetic predisposition, life experiences, and phobias.

Our research has highlighted the promising potential of expert systems to revolutionize the way we diagnose anxiety. These AI-based tools can enhance diagnostic accuracy by efficiently analyzing large volumes of data. Moreover, they can consider subjective factors and identify patterns that may be crucial for early and accurate anxiety identification.

However, it is important to emphasize that, despite technological advancements, human intervention and ongoing support from mental health professionals are essential for anxiety treatment. Expert systems should be viewed as complementary tools that can assist professionals, but not replace them. Empathy, support, and understanding provided by healthcare professionals remain crucial in caring for individuals facing anxiety.

In summary, this article underscores the complexity of anxiety and the promising contribution of expert systems to diagnosis. We hope that these findings drive future research and improve the quality of life for those suffering from anxiety. The integration of traditional clinical approaches with cutting-edge technology may represent a significant step in the fight against anxiety and its harmful effects.

References

1. Feigenbaum, E.A.: EXPERT SYSTEMS IN THE 1980s Material on the INTERNIST and SECS programs was adapted from the 1980 SUMEX-AIM. (1980)
2. Boss, R.W.: What Is An Expert System? ERIC Digest. 1–4 (1991)
3. Ströhle, A., Gensichen, J., Domschke, K.: Diagnostik und Therapie von Angsterkrankungen. Dtsch Arztebl Int. 115, 611–620 (2018). https://doi.org/10.3238/arztebl.2018.0611
4. Diana Seabra: Um em cada cinco portugueses sofreram sintomas de ansiedade e depressão durante a pandemia, (2022)
5. Cristie Glasheen, Kathryn Batts, Rhonda Karg: Table 3.15 DSM-IV to DSM-5 Generalized Anxiety Disorder Comparison, https://www.ncbi.nlm.nih.gov/books/NBK519704/table/ch3.t15/
6. UNIVERSITY of WISCONSIN–MADISON: Symptom Checklist-90 (SCL90), https://arc.psych.wisc.edu/self-report/symptom-checklist-90-scl90/
7. Luis Faria: Aplicação da Lógica Difusa aos SBC.
8. Ramzan, M., Hamid, M., Alhussan, A.A., AlEisa, H.N., Abdallah, H.A.: Accurate Prediction of Anxiety Levels in Asian Countries Using a Fuzzy Expert

System. Healthcare (Switzerland). 11, (2023). https://doi.org/10.3390/healthcare11111594
9. Tutun, S., Johnson, M.E., Ahmed, A., Albizri, A., Irgil, S., Yesilkaya, I., Ucar, E.N., Sengun, T., Harfouche, A.: An AI-based Decision Support System for Predicting Mental Health Disorders. Information Systems Frontiers. 25, 1261–1276 (2023). https://doi.org/10.1007/s10796-022-10282-5