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Knowledge-Based System for Diagnosing *Colon Cancer*

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Abstract: *Colon cancer is a prevalent and life-threatening disease, necessitating accurate and timely diagnosis for effective treatment and improved patient outcomes. This research paper presents the development of a knowledge-based system for diagnosing colon cancer using the CLIPS language. Knowledge-based systems offer the potential to assist healthcare professionals in making informed diagnoses by leveraging expert knowledge and reasoning mechanisms. The methodology involves acquiring and structuring medical knowledge specific to colon cancer, followed by the implementation of a knowledge-based system using CLIPS. The system's design integrates relevant medical databases and employs advanced reasoning mechanisms to facilitate accurate diagnosis. Evaluation results demonstrate the system's effectiveness, with high accuracy and sensitivity rates compared to existing methods. The findings highlight the potential of knowledge-based systems in improving clinical practice and patient care. The research contributes to the growing field of medical informatics by demonstrating the feasibility and effectiveness of CLIPS-based knowledge systems for colon cancer diagnosis. Future research can focus on enhancing system performance and expanding its scope to encompass other types of cancer diagnoses.*

Keywords: Artificial intelligence, expert system, CLIPS

INTRODUCTION

Colon cancer, also known as colorectal cancer, is a significant global health concern characterized by the uncontrolled growth of abnormal cells in the colon or rectum. It ranks as the third most commonly diagnosed cancer and the second leading cause of cancer-related deaths worldwide. Early detection and accurate diagnosis are crucial for effective treatment and improved patient outcomes. However, the complexity and diversity of colon cancer symptoms pose challenges for healthcare professionals in making timely and precise diagnoses [1].

In recent years, there has been a growing interest in the development of computer-aided diagnosis systems to support medical professionals in diagnosing various diseases, including cancer. Knowledge-based systems, a subset of artificial intelligence, have emerged as promising tools for assisting in medical diagnostics. These systems leverage expert knowledge and reasoning mechanisms to analyze patient data and generate accurate diagnoses [2].

This research paper focuses on the development of a knowledge-based system for diagnosing colon cancer using the CLIPS (C Language Integrated Production System) language. CLIPS provides a robust and flexible platform for building rule-based expert systems. By employing CLIPS, we aim to create a system that can effectively utilize medical knowledge and reasoning techniques to assist in the diagnosis of colon cancer [3].

The primary objective of this research is to design and implement a knowledge-based system capable of accurately diagnosing colon cancer. By integrating domain-specific medical knowledge, the system will analyze patient information, such as symptoms, medical history, and diagnostic test results, to provide healthcare professionals with valuable insights and support in making informed decisions.

In this paper, we will first review the existing literature on computer-aided diagnosis systems and discuss the different approaches employed in the context of colon cancer diagnosis. We will highlight the advantages and limitations of knowledge-based systems, emphasizing their potential to enhance accuracy and efficiency in medical diagnostics.

The methodology section will outline the steps involved in developing the knowledge-based system. This includes acquiring and structuring medical knowledge specific to colon cancer and formulating rules and reasoning mechanisms within the CLIPS framework. We will discuss the integration of the system with relevant medical databases and knowledge sources to enhance its diagnostic capabilities.

The evaluation of the developed system will assess its performance in diagnosing colon cancer. We will employ established evaluation metrics, such as accuracy, sensitivity, and specificity, to measure the system's effectiveness compared to existing methods or standards. The results will be discussed, highlighting the system's strengths and potential areas for improvement.

BACKGROUND:

1. Expert Systems: Expert systems are a branch of artificial intelligence (AI) that aim to replicate the decision-making abilities of human experts in specific domains. These systems utilize knowledge-based techniques to capture and represent expert knowledge in a structured manner. By employing rules, heuristics, and inference mechanisms, expert systems can reason and provide solutions or recommendations for complex problems Figure 1 illustrate the expert system architecture [4].

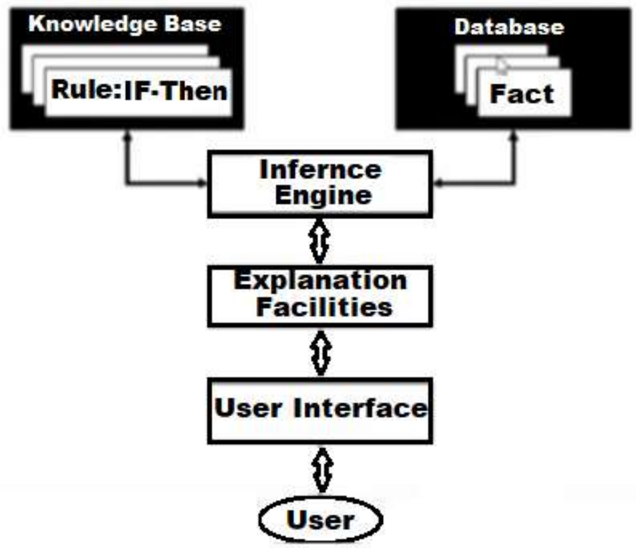

Figure 1: Knowledge Based System Architecture

The knowledge base, in the context of a knowledge-based system, refers to a central repository or storehouse of information and expertise that is utilized by the system to make informed decisions, perform reasoning, and provide solutions or recommendations. It is a structured collection of knowledge, facts, rules, heuristics, and relationships that represent the domain-specific expertise of human experts or specialists [4].

The knowledge base serves as the foundation for the knowledge-based system's reasoning and problem-solving capabilities. It contains a wealth of information about the domain of interest, such as medical conditions, symptoms, diagnostic criteria, treatment guidelines, and other relevant facts. The knowledge base is designed to capture and organize this knowledge in a way that enables the system to access, retrieve, and utilize it during the decision-making process [5].

The knowledge within the knowledge base is typically represented in a formal or semi-formal manner, such as through rules, ontologies, frames, or other knowledge representation languages. These representations enable the system to process and manipulate the knowledge effectively, facilitating inference and reasoning.

The knowledge base is dynamic and can be updated and refined as new information becomes available or as the domain evolves. It is continuously enhanced with new insights, research findings, and expert input to ensure the knowledge-based system remains up to date and reflects the current state of knowledge in the domain.

The database includes a set of facts used to match against the IF (condition) parts of rules stored in the knowledge base.

The inference engine is a fundamental component of a knowledge-based system that performs logical reasoning and inference based on the knowledge and rules stored in the knowledge base. It is responsible for interpreting the input data, applying the rules, and generating meaningful output or conclusions.

The inference engine utilizes various reasoning mechanisms to draw conclusions and make inferences based on the available knowledge. These mechanisms include rule-based reasoning, forward chaining, backward chaining, and logical deduction. The inference engine evaluates the facts, rules, and relationships in the knowledge base to derive new information or make decisions based on the given input [3].

When presented with a set of facts or data, the inference engine matches these facts against the rules stored in the knowledge base. It applies the rules that are relevant to the given facts and uses logical reasoning to reach a conclusion or recommendation. The inference engine can evaluate multiple rules simultaneously and handle complex relationships and dependencies among the rules [3].

Explanation facilities refer to the capabilities of a knowledge-based system to provide explanations or justifications for its reasoning and decision-making processes. These facilities aim to enhance the transparency and understandability of the system's outputs and enable users to comprehend how the system arrived at its conclusions [2].

The user interface (UI) of a knowledge-based system is the means by which users interact with the system to input data, receive outputs, and navigate through the system's functionalities. It serves as the bridge between the users and the underlying knowledge and reasoning processes of the system [3].

In the medical field, expert systems have shown great potential for assisting healthcare professionals in diagnosing various diseases, including cancer. These systems integrate medical knowledge, clinical guidelines, and patient data to analyze symptoms, interpret test results, and generate accurate diagnoses. By providing valuable insights and decision support, expert systems contribute to improved efficiency, accuracy, and consistency in medical diagnostics.

2. CLIPS Language: CLIPS (C Language Integrated Production System) is a widely used rule-based programming language and development environment specifically designed for building expert systems. It provides a powerful framework for knowledge representation, rule formulation, and inference execution. CLIPS incorporates a forward chaining inference engine that allows rules to be fired based on the available data and the defined rule conditions [5].

   The flexibility and efficiency of CLIPS make it suitable for developing knowledge-based systems in various domains, including healthcare. It supports the creation of rule-based systems that can capture expert knowledge and perform complex reasoning tasks. By leveraging the capabilities of CLIPS, researchers and developers can build robust and effective expert systems for medical diagnostics.

3. Colon Cancer: Colon cancer, also known as colorectal cancer, is a malignant tumor that arises in the colon or rectum. It typically develops from benign polyps, which are abnormal growths on the inner lining of the colon or rectum. Colon cancer is a significant global health issue, accounting for a substantial number of cancer-related deaths worldwide [6].

   The early detection of colon cancer plays a crucial role in successful treatment and patient survival rates. However, diagnosing colon cancer can be challenging due to the variety of symptoms and the need for accurate differentiation from other gastrointestinal disorders. Common symptoms include changes in bowel habits, rectal bleeding, abdominal pain, and unexplained weight loss.

   Diagnosing colon cancer typically involves a combination of procedures, including physical examinations, medical history assessment, laboratory tests, imaging techniques (such as colonoscopy and computed tomography), and biopsy analysis. Integrating these diagnostic data and interpreting the results accurately is essential for timely and precise diagnosis.

   Given the complexity of colon cancer diagnosis, the development of knowledge-based systems using the CLIPS language presents a promising approach. Such systems have the potential to leverage expert knowledge, reasoning mechanisms, and patient data to provide healthcare professionals with valuable decision support, contributing to improved diagnosis and treatment outcomes for colon cancer patients.

LITERATURE REVIEW:

Previous Studies

Several studies have demonstrated the potential of expert systems to enhance diagnostic accuracy and improve patient outcomes.

The study [6] reported that a rule-based expert system achieved high sensitivity and specificity in detecting adenomas during colonoscopy.

The study in [7] found that a machine learning algorithm could accurately differentiate between normal colon tissue and cancerous tissue using endoscopic images.

The study [8] utilized machine learning algorithms to analyze a large dataset of colonoscopy images. The system achieved high accuracy in detecting colon polyps and distinguishing between benign and malignant cases.

They study [9] focused on integrating clinical and genetic data to develop a predictive model for colon cancer risk assessment.

They study [10] developed a knowledge-based system using the MYCIN framework to provide decision support in colon cancer diagnosis. The system utilized a rule-based approach, incorporating expert knowledge and patient data to generate accurate diagnoses.

Additionally, expert systems have shown potential to improve efficiency and reduce costs associated with screening [11]. However, challenges related to data quality, system integration, and user acceptance have been identified as barriers to the widespread adoption of expert systems in clinical practice. Several studies have proposed solutions to address these challenges, including the use of standardized data formats and the involvement of stakeholders in system design and implementation. Overall, the literature review highlights the promising potential of expert systems in colon cancer screening and the need for continued research and development to fully realize this potential [12][13].

Gap between Previous Studies:

Despite the valuable contributions made by previous studies, several gaps and opportunities for further research can be identified. First, while machine learning approaches have shown promise, the interpretability and transparency of the generated models remain a challenge. Knowledge-based systems, such as expert systems, offer the advantage of transparent reasoning and the ability to capture domain-specific knowledge.

Furthermore, the utilization of the CLIPS language in developing knowledge-based systems for colon cancer diagnosis appears to be relatively unexplored in the existing literature. This research paper aims to address this gap by demonstrating the effectiveness and feasibility of a CLIPS-based knowledge system.

Another important gap lies in the integration of diverse data sources, including medical images, genetic data, and clinical information, into a unified diagnostic system. The synergistic combination of these data types has the potential to enhance the accuracy and precision of colon cancer diagnosis.

Lastly, while previous studies have focused on specific aspects of colon cancer diagnosis, such as risk assessment or polyp detection, a comprehensive knowledge-based system capable of covering the entire diagnostic process is lacking. This research paper aims to bridge this gap by developing a holistic knowledge-based system that encompasses various diagnostic factors and provides comprehensive decision support.

Although, there are many expert systems in Medicine field, there are no expert system for diagnosing *Colon Cancer* diseases. That is why we are proposing expert system for diagnosing and treating *Colon Cancer* problems.

KNOWLEDGE REPRESENTATION

There 14 rules for the colon cancer diagnoses that are represented using CLIPS expert system language [1]:

Rules for the diagnosis of colon cancer diseases:

1. If a patient experiences persistent changes in bowel habits such as diarrhea or constipation, or if they notice a significant change in the consistency or appearance of their stools, then colon cancer should be considered as a possible diagnosis.
2. If a patient experiences persistent abdominal pain, cramping, or bloating, especially in combination with changes in bowel habits, then colon cancer should be considered as a possible diagnosis
3. If a patient experiences rectal bleeding, particularly if it is bright red or occurs in large amounts, then colon cancer should be considered as a possible diagnosis.
4. If a patient experiences unexplained weight loss, fatigue, or weakness, then colon cancer should be considered as a possible diagnosis.

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5. If the patient is over 50 years old and has experienced persistent changes in bowel habits, then suspect colon cancer.
6. If the patient has a family history of colon cancer and presents with unexplained weight loss, then consider colon cancer as a possibility.
7. If the patient complains of rectal bleeding and has a history of inflammatory bowel disease, then evaluate for colon cancer.
8. If the patient has iron deficiency anemia and abdominal pain, then investigate for colon cancer.
9. If the patient has a positive fecal occult blood test and abdominal bloating, then consider colon cancer as a potential diagnosis.
10. If the patient has a large polyp detected during a colonoscopy and has a history of adenomas, then suspect colon cancer.
11. If the patient presents with obstructive symptoms, such as nausea, vomiting, and abdominal distention, then evaluate for colon cancer.
12. If the patient has a palpable mass in the abdomen and experiences unexplained fatigue, then consider colon cancer as a possible cause.
13. If the patient has unexplained iron deficiency anemia and a family history of colon cancer, then suspect colon cancer.
14. If the patient presents with bowel obstruction and a previous history of colorectal polyps, then evaluate for colon cancer.

Proposed Expert System

An expert system has been established that diagnoses colon cancer. The expert system helps doctors and facilitates the process of detecting the disease clearly and well. The system also diagnoses colon cancer by showing a list of symptoms related to colon cancer. The expert system was programmed using the CLIPS language. The expert system diagnoses diseases related to colon cancer through a system consisting of some lists that make it easier for the user to use.

At first, a user interface will appear that contains four tasks. If the user clicks on the "Start" icon, the user will see an interface that contains a list of all the symptoms. The user will choose all the symptoms related to the disease he wants.

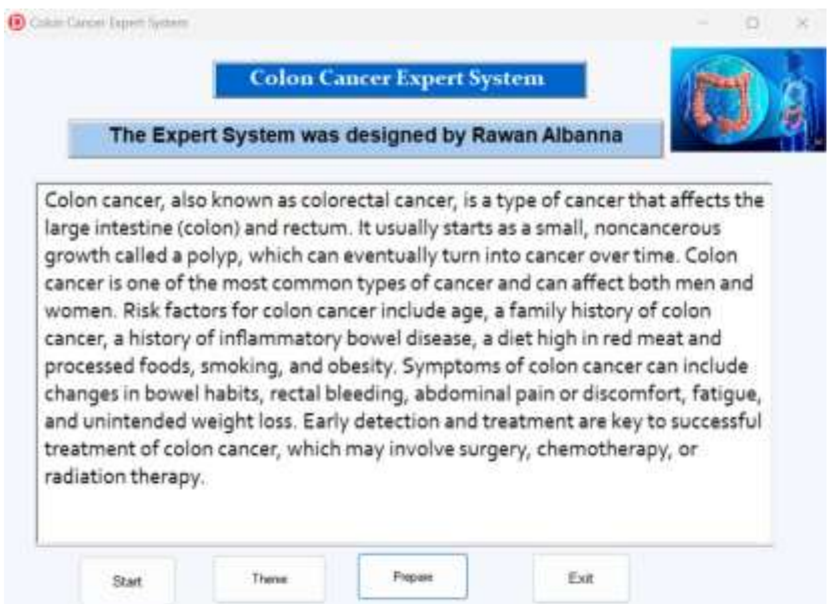

Figure 2: user interface

Then appear list of symptoms for the user to choose the symptoms that appear on the patient.

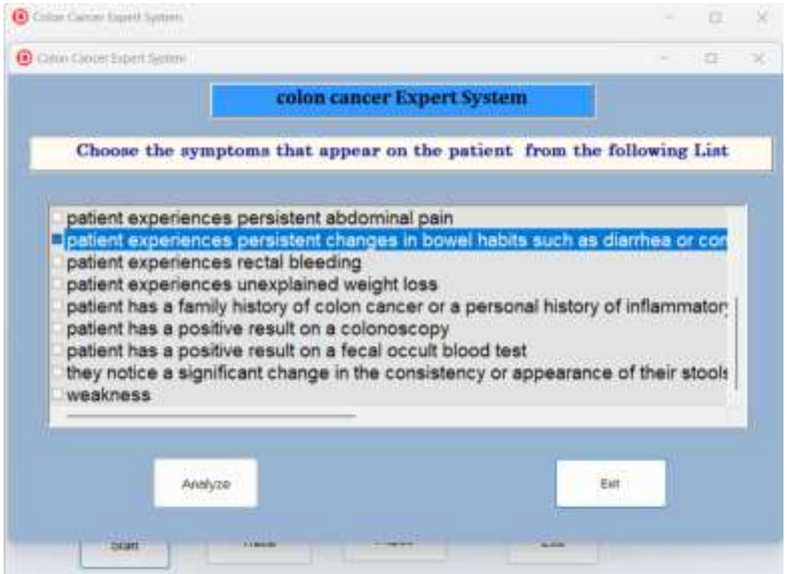

Figure 3: Symptom list

Then appear the possible diagnosis according to the selected symptoms for the user to show the Favorable Conditions and Survival and spread and an image of the diagnosis.

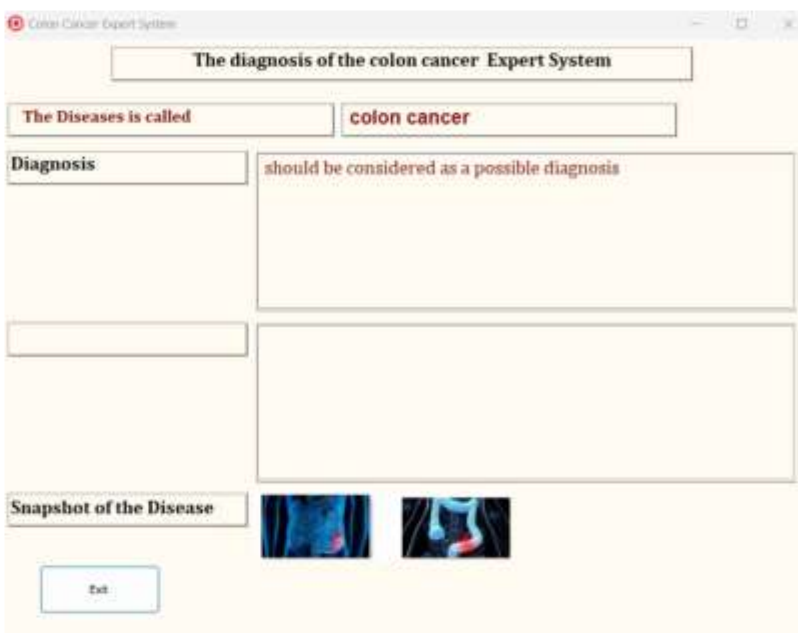

Figure 4: Diagnosis of the disease

Conclusion:

Finally, the utilization of expert systems in colon cancer screening has the potential to revolutionize the field by improving accuracy, efficiency, and accessibility. While challenges exist, their benefits are significant. By leveraging the expertise of computer systems, healthcare professionals can enhance their decision-making capabilities, leading to earlier detection and improved patient outcomes. Continued research, development, and implementation efforts are necessary to realize the full potential of expert systems in colon cancer screening and ensure their successful integration into clinical practice

EXPERT SYSTEM SOURCE CODE:

```
(defrule disease1
(patient experiences persistent changes in bowel habits such as diarrhea or constipation)
(they notice a significant change in the consistency or appearance of their stools)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "1"  crlf )
)
(defrule disease2
(patient experiences persistent abdominal pain)
(cramping)
(bloating)
(especially in combination with changes in bowel habits)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "2"  crlf )
)
(defrule disease3
(patient experiences rectal bleeding)
(particularly if it is bright red or occurs in large amounts)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "3"  crlf )
)
(defrule disease4
(patient experiences unexplained weight loss)
(fatigue)
```

```
(weakness)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "4"  crlf )
)
(defrule disease5
(patient has a family history of colon cancer or a personal history of inflammatory bowel diseasen)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "5"  crlf )
)
(defrule disease6
(patient has a positive result on a fecal occult blood test)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "6"  crlf )
)
(defrule disease7
(patient has a positive result on a colonoscopy)
(biopsy)
(other imaging test that shows abnormalities in the colon)
(not (disease identified))
=>
(assert (disease identified))
(printout fdatao "7"  crlf )
)
(defrule endline
(disease identified)
=>
```

```
  (close fdatao)
)
(defrule readdata
  (declare (salience 1000))
  (initial-fact)
  ?fx <- (initial-fact)
=>
  (retract ?fx)
  (open "data.txt" fdata "r")
  (open "result.txt" fdatao "w")
  (bind ?symptom1 (readline fdata))
  (bind ?symptom2 (readline fdata))
  (bind ?symptom3 (readline fdata))
  (bind ?symptom4 (readline fdata))
  (bind ?symptom5 (readline fdata))
  (bind ?symptom6 (readline fdata))
  (bind ?symptom7 (readline fdata))
  (assert-string (str-cat "(" ?symptom1 ")"))
  (assert-string (str-cat "(" ?symptom2 ")"))
  (assert-string (str-cat "(" ?symptom3 ")"))
  (assert-string (str-cat "(" ?symptom4 ")"))
  (assert-string (str-cat "(" ?symptom5 ")"))
  (assert-string (str-cat "(" ?symptom6 ")"))
  (assert-string (str-cat "(" ?symptom7 ")"))
  (close fdata)
)
```

References:

1. Abunasser, B.S., Al-Hiealy, M.R.J., Zaqout, I.S., Abu-Naser, S.S. Literature review of breast cancer detection using machine learning algorithms, AIP Conference Proceedings, 2023, 2808
2. Al-Zamily, J.Y.I., Ariffin, S.B., Abu Naser, S.S.M. A survey of cryptographic algorithms with deep learning, AIP Conference Proceedings, 2023, 2808, 050002
3. Barhoom, A.M.A., Jubair, M.R., Abu-Naser, S.S. A survey of bone abnormalities detection using machine learning algorithms, AIP Conference Proceedings, 2023, 2808, 040009
4. Abunasser, B. S. Daud,S. M., Zaqout, I., Abu-Naser S. S. Abunaser - A Novel Data Augmentation Algorithm For Datasets With Numerical Features. Journal of Theoretical and Applied Information Technology, 2023, Vol. 101. No. 11.
5. Alrakhawi, H. A., Jamiat, N., Umar, I. N., Abu-Naser, S. S. Improvement of Students Achievement by Using Intelligent Tutoring Systems - A Bibliometric Analysis and Reviews. Journal of Theoretical and Applied Information Technology, 2023, Vol. 101. No. 11.
6. Abunasser, B.S., Al-Hiealy, M.R.J., Zaqout, I.S., Abu-Naser, S.S. Convolution Neural Network for Breast Cancer Detection and Classification Using Deep Learning. Asian Pacific journal of cancer prevention: APJCP, 2023, 24(2), pp. 531–544
7. Alrakhawi, H. A., Jamiat, N., Abu-Naser, S. S. Intelligent Tutoring Systems in Education: A Systematic Review of Usage, Tools, Effects and Evaluation. Journal of Theoretical and Applied Information Technology, 2023, Vol. 101. No. 4, pp. 1205-1226.
8. Zarandah, Q. M. M., Daud, S. M., Abu-Naser, S. S. A Systematic Literature Review Of Machine and Deep Learning-Based Detection And Classification Methods for Diseases Related To the Respiratory System, Journal of Theoretical and Applied Information Technology, 2023, Vol. 101. No. 4, pp. 1273-1296.
9. Alkayyali, Z. K. D., Idris, S. A. B, Abu-Naser, S. S. A Systematic Literature Review of Deep and Machine Learning Algorithms in Cardiovascular Diseases Diagnosis, Journal of Theoretical and Applied Information Technology, 2023, Vol. 101. No. 4, pp. 1353-1365.
10. Abunasser, B. S. Daud,S. M., Zaqout,I., Abu-Naser S. S. Convolution Neural Network For Breast Cancer Detection And Classification - Final Results. Journal of Theoretical and Applied Information Technology, 2023, Vol. 101. No. 1, pp. 315-329.
11. Taha, A. M. H., Ariffin, D. S. B. B., Abu-Naser, S. S. A Systematic Literature Review of Deep and Machine Learning Algorithms in Brain Tumor and Meta-Analysis, Journal of Theoretical and Applied Information Technology, 2023, Vol. 101. No. 1, pp. 21-36.
12. Abu Ghosh, M.M., Atallah, R.R., Abu Naser, S.S. Secure mobile cloud computing for sensitive data: Teacher services for Palestinian higher education institutions. International Journal of Grid and Distributed Computing, 2016, vol. 9, no. 2, pp. 17–22
13. Abunasser, B. S., AL-Hiealy, M. R. J., Zaqout, I. S. and Abu-Naser, S. S. “Breast Cancer Detection and Classification using Deep Learning Xception Algorithm” International Journal of Advanced Computer Science and Applications(IJACSA), 13(7),223-228, 2022.
14. Abunasser, B.S., AL-Hiealy, M.R. J., Barhoom, A. M. Almasri A. R. and Abu-Naser, S. S. “Prediction of Instructor Performance using Machine and Deep Learning Techniques” International Journal of Advanced Computer Science and Applications(IJACSA), 13(7), 78-83, 2022.
15. Alayoubi, M.M., Arekat, Z.M., Al Shobaki, M.J., Abu-Naser, S.S. The Impact of Work Stress on Job Performance Among Nursing Staff in Al-Awda Hospital. Foundations of Management, 2022, 14(1), pp. 87–108
16. Albatish, I.M., Abu-Naser, S.S. Modeling and controlling smart traffic light system using a rule based system. Proceedings - 2019 International Conference on Promising Electronic Technologies, ICPET 2019, 2019, pp. 55–60, 8925318
17. Almasri, A., Obaid, T., Abumandil, M.S.S., ...Mahmoud, A.Y., Abu-Naser, S.S. Mining Educational Data to Improve Teachers’ Performance. Lecture Notes in Networks and Systems, 2023, 550 LNNS, pp. 243–255
18. Almasri, A.R., Yahaya, N.A., Abu-Naser, S.S. Instructor Performance Modeling For Predicting Student Satisfaction Using Machine Learning - Preliminary Results. Journal of Theoretical and Applied Information Technology, 2022, 100(19), pp. 5481–5496
19. Arqawi, S., Atieh, K.A.F.T., Shobaki, M.J.A.L., Abu-Naser, S.S., Abu Abdulla, A.A.M. Integration of the dimensions of computerized health information systems and their role in improving administrative performance in Al-Shifa medical complex, Journal of Theoretical and Applied Information Technology, 2020, vol. 98, no. 6, pp. 1087–1119
20. Arqawi, S.M., Abu Rumman, M.A., Zitawi, E.A., ...Abunasser, B.S., Abu-Naser, S.S. Predicting Employee Attrition And Performance Using Deep Learning. Journal of Theoretical and Applied Information Technology, 2022, 100(21), pp. 6526–6536
21. Arqawi, S.M., Zitawi, E.A., Rabaya, A.H., Abunasser, B.S., Abu-Naser, S.S., “Predicting University Student Retention using Artificial Intelligence”, International Journal of Advanced Computer Science and Applications , 2022, vol. 13, no. 9, pp. 315–324
22. Barhoom, A.M.A., Al-Hiealy, M.R.J., Abu-Naser, S.S. Bone Abnormalities Detection and Classification Using Deep Learning-VGG16 Algorithm. Journal of Theoretical and Applied Information Technology, 2022, 100(20), pp. 6173–6184
23. Barhoom, A.M.A., Al-Hiealy, M.R.J., Abu-Naser, S.S. Deep Learning-Xception Algorithm for Upper Bone Abnormalities Classification. Journal of Theoretical and Applied Information Technology, 2022, 100(23), pp. 6986–6997
24. El-Habil, B.Y., Abu-Naser, S.S. Global Climate Prediction Using Deep Learning. Journal of Theoretical and Applied Information Technology, 2022, 100(24), pp. 4824–4838
25. Eneizan, B., Obaid, T., Abumandil, M.S.S., ...Arif, K., Abulehia, A.F.S. Acceptance of Mobile Banking in the Era of COVID-19. Lecture Notes in Networks and Systems, 2023, 550 LNNS, pp. 29–42
26. Alzamily, J. Y. I., Ariffin, S. B., Abu-Naser, S. S. Classification of Encrypted Images Using Deep Learning –Resnet50. Journal of Theoretical and Applied Information Technology, 2022, 100(21), pp. 6610–6620
27. Mady, S.A., Arqawi, S.M., Al Shobaki, M.J., Abu-Naser, S.S. Lean manufacturing dimensions and its relationship in promoting the improvement of production processes in industrial companies. International Journal on Emerging Technologies, 2020, vol. 11, no. 3, pp. 881–896
28. Obaid, T., Eneizan, B., Naser, S.S.A., ...Abualrejal, H.M.E., Gazem, N.A. Factors Contributing to an Effective E- Government Adoption in Palestine. Lecture Notes on Data Engineering and Communications Technologies, 2022, 127, pp. 663–676
29. Obaid, T., Eneizan, B., Abumandil, M.S.S., ...Abu-Naser, S.S., Ali, A.A.A. Factors Affecting Students’ Adoption of E-Learning Systems During COVID-19 Pandemic: A Structural Equation Modeling Approach. Lecture Notes in Networks and Systems, 2023, 550 LNNS, pp. 227–242
30. Saleh, A., Sukaik, R., Abu-Naser, S.S. Brain tumor classification using deep learning. Proceedings - 2020 International Conference on Assistive and Rehabilitation Technologies, iCareTech 2020, 2020, pp. 131–136, 9328072
31. Abueleiwa, M. H., et al. (2022). "Rule Based System for Diagnosing Bean Diseases and Treatment." International Journal of Engineering and Information Systems (IJEAIS) 6(5): 67-74.
32. Abu-Jamie, T. N., et al. (2021). "Diagnosing Cough Problem Expert System Using CLIPS." International Journal of Academic Information Systems Research (IJAISR) 5(5): 79-90.
33. Abu-Saqer, M. M., et al. (2019). "Developing an Expert System for Papaya Plant Disease Diagnosis." International Journal of Academic Engineering Research (IJAER) 3(4): 14-21.
34. Abu-Saqer, M. M., et al. (2019). "Knowledge Based System for Uveitis Disease Diagnosis." International Journal of Academic Information Systems Research (IJAISR) 3(5): 18-25.
35. Aish, M. A., et al. (2021). "Lower Back Pain Expert System Using CLIPS." International Journal of Academic Information Systems Research (IJAISR) 5(5): 57-67.
36. Alfarra, A. H., et al. (2021). "An Expert System for Neck Pain Diagnosis." International Journal of Academic Information Systems Research (IJAISR) 5(7): 1-8.
37. Al-Ghoul, M. M., et al. (2022). "Knowledge Based System for Diagnosing Custard Apple Diseases and Treatment." International Journal of Academic Engineering Research (IJAER) 6(5): 41-45.
38. Alkahlout, M. A., et al. (2021). "Expert System Diagnosing Facial-Swelling Using CLIPS."
39. Alkahlout, M. A., et al. (2021). "Expert System for Throat Problems Using SL5 Object." International Journal of Academic Information Systems Research (IJAISR) 5(5): 68-78.
40. Alkahlout, M. A., et al. (2021). "Knowledge Based System for Diagnosing Throat Problem CLIPS and Delphi languages." International Journal of Academic Engineering Research (IJAER) 5(6): 7-12.
41. AlKayyali, Z. K., et al. (2022). "Prediction of Student Adaptability Level in e-Learning using Machine and Deep Learning Techniques." International Journal of Academic and Applied Research (IJAAR) 6(5): 84-96.
42. Almadhoun, H. R., et al. (2020). "An Expert System for Diagnosing Coronavirus (COVID-19) Using SL5." International Journal of Academic Engineering Research (IJAER) 4(4): 1-9.
43. Al-Masawabe, M. M., et al. (2021). "Expert System for Short-term Abdominal Pain (Stomach Pain) Diagnosis and Treatment." International Journal of Academic Information Systems Research (IJAISR) 5(5): 37-56.
44. Al-Qadi, M. H., et al. (2022). "Developing an Expert System to Diagnose Tomato Diseases." International Journal of Academic Engineering Research (IJAER) 6(5): 34-40.
45. AlQatrawi, M. J., et al. (2022). "Rule Based System for Diagnosing Lablab Problems." International Journal of Academic and Applied Research (IJAAR) 6(5): 249-256.
46. Al-Saloul, N. J., et al. (2022). "A Knowledge Based System for Cucumber Diseases Diagnosis." International Journal of Academic Information Systems Research (IJAISR) 6(5): 29-45.
47. Alsaqqa, A. H., et al. (2021). "Knowledge Based for Tooth Problems." International Journal of Academic Information Systems Research (IJAISR) 5(5).
48. Barhoom, A. M., et al. (2022). "Prediction of Heart Disease Using a Collection of Machine and Deep Learning Algorithms." International Journal of Engineering and Information Systems (IJEAIS) 6(4): 1-13.
49. Barhoom, A., et al. (2022). "Sarcasm Detection in Headline News using Machine and Deep Learning Algorithms." International Journal of Engineering and Information Systems (IJEAIS) 6(4): 66-73.
50. Dheir, I. M. and S. S. Abu-Naser (2022). "Classification of Anomalies in Gastrointestinal Tract Using Deep Learning." International Journal of Academic Engineering Research (IJAER) 6(3): 15-28.
51. Dheir, I., et al. (2019). "Knowledge Based System for Diagnosing Guava Problems." International Journal of Academic Information Systems Research (IJAISR) 3(3): 9-15.
52. El-Habibi, M. F., et al. (2022). "A Proposed Expert System for Obstetrics & Gynecology Diseases Diagnosis." International Journal of Academic Multidisciplinary Research (IJAMR) 6(5): 305-321.
53. Elhabil, B. Y., et al. (2021). "An Expert System for Ankle Problems." International Journal of Engineering and Information Systems (IJEAIS) 5(4).
54. Elhabil, B. Y., et al. (2021). "Expert System for Hib Problems."
55. El-Hamarnah, H. A., et al. (2022). "Proposed Expert System for Pear Fruit Diseases." International Journal of Academic and Applied Research (IJAAR) 6(5): 237-248.
56. Hamadaqa, M. H. M., et al. (2021). "Hair Loss Diagnosis Expert System and Treatment Using CLIPS." International Journal of Academic Engineering Research (IJAER) 5(5): 37-42.
57. Khalil, A. J., et al. (2019). "Apple Trees Knowledge Based System." International Journal of Academic Engineering Research (IJAER) 3(9): 1-7.
58. LAfi, O. I., et al. (2022). "A Proposed Expert System for Broccoli Diseases Diagnosis." International Journal of Engineering and Information Systems (IJEAIS) 6(5): 43-51.
59. Mansour, A. I. and S. S., et al. (2021). "Expert system for the diagnosis of high blood pressure diseases."
60. Mansour, A. I., et al. (2021). "An Expert System for Diagnosing Cough Using SL5 Object." International Journal of Academic Engineering Research (IJAER) 5(6): 13-27.
61. Masri, N., et al. (2019). "Survey of Rule-Based Systems." International Journal of Academic Information Systems Research (IJAISR) 3(7): 1-23.
62. Megdad, M. M., et al. (2022). "Fraudulent Financial Transactions Detection Using Machine Learning." International Journal of Academic Information Systems Research (IJAISR) 6(3): 30-39.
63. Megdad, M. M., et al. (2022). "Mint Expert System Diagnosis and Treatment." International Journal of Academic Information Systems Research (IJAISR) 6(5): 22-28.
64. Obaid, T., et al. (2022). Factors Contributing to an Effective E-Government Adoption in Palestine. International Conference of Reliable Information and Communication Technology, Springer, Cham.
65. Radwan, H. I., et al. (2022). "A Proposed Expert System for Passion Fruit Diseases." International Journal of Academic Engineering Research (IJAER) 6(5): 24-33.
66. Sababa, R. Z., et al. (2022). "A Proposed Expert System for Strawberry Diseases Diagnosis." International Journal of Engineering and Information Systems (IJEAIS) 6(5): 52-66.
67. Salman, F. M. and S. S. Abu-Naser (2022). "Classification of Real and Fake Human Faces Using Deep Learning." International Journal of Academic Engineering Research (IJAER) 6(3): 1-14.
68. Samhan, L. F., et al. (2021). "Expert System for Knee Problems Diagnosis." International Journal of Academic Information Systems Research (IJAISR) 5(4):59-66.
69. Samhan, L. F., et al. (2022). "Classification of Alzheimer's Disease Using Convolutional Neural Networks." International Journal of Academic Information Systems Research (IJAISR) 6(3): 18-23.
70. Taha, A. M., et al. (2022). "Gender Prediction from Retinal Fundus Using Deep Learning." International Journal of Academic Information Systems Research (IJAISR) 6(5): 57-63.