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Medical Expert Systems in Ambulance Care

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الأنظمة الخبيرة في تقديم رعاية الطوارئ الطبية في سيارات الإسعاف

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Abstract:
Daily incidents significantly impact the workflow of ambulance and healthcare personnel, whose critical role involves providing immediate medical treatment and facilitating transportation to hospitals. This study presents the design of a medical expert system aimed at enhancing first-aid response in ambulances and educating users on fundamental first-aid principles. The proposed system integrates a comprehensive knowledge base that catalogs disease symptoms and corresponding treatments, functioning similarly to a medical professional's guidance. While the system relies on pre-programmed symptoms, it allows for the continuous addition of new symptoms and diseases, ensuring adaptability in emergencies. This expert system is particularly beneficial for novice healthcare providers, equipping them with reliable diagnostic support and improving patient outcomes during medical emergencies.

Keywords: Medical Expert System, First Aid, Ambulance Services, Healthcare Personnel, Knowledge-Based Systems, Emergency Medicine, Diagnosis and Treatment, Symptom Management, Medical Education.

الملخص
تؤثر الحوادث اليومية بشكل كبير على سير العمل لدى طاقم الإسعاف والعاملين في مجال الرعاية الصحية، حيث يتضمن دورهم الحيوي تقديم العلاج الطبي الفوري وتسهيل النقل إلى المستشفيات. تقدم هذه الدراسة تصميم نظام خبير طبي يهدف إلى تعزيز استجابة الإسعاف الأولي في سيارات الإسعاف وتعليم المستخدمين مبادئ الإسعاف الأولي الأساسية. يدمج النظام المقترح قاعدة معرفية شاملة تسجل أعراض الأمراض والعلاجات المقابلة، مما يعمل بشكل مشابه لتوجيهات المحترفين الطبيين. بينما يعتمد النظام على الأعراض المبرمجة مسبقًا، فإنه يسمح بإضافة أعراض وأمراض جديدة باستمرار، مما يضمن التكيف في حالات الطوارئ. يعد هذا النظام الخبير مفيدًا بشكل خاص لمقدمي الرعاية الصحية المبتدئين، حيث يزودهم بدعم تشخيصي موثوق ويعزز نتائج المرضى خلال الحالات الطبية الطارئة.

الكلمات المفتاحية: النظم الخبيرة الصحية، الإسعاف الأولي، خدمات الإسعاف، العاملون في الرعاية الصحية، أنظمة قائمة على المعرفة، الطب الطارئ، التشخيص والعلاج، إدارة الأعراض، التعليم الطبي.

Introduction

Daily incidents constitute a significant portion of the workday for ambulance and healthcare personnel, whose primary mission at the incident site involves medical treatment and transportation to the hospital. A medical expert system contains a knowledge base of disease symptoms and their treatments. The information provided by the medical expert system is comparable to that offered by a doctor or expert in emergency medicine. The user or patient is prompted to respond, and based on these responses, the appropriate therapy is displayed on the screen. However, a limitation of this medical expert system is that it only includes symptoms pre-programmed into the knowledge base. Consequently, new symptoms and diseases can be added to the knowledge base at any time.

The Necessity for This Work

The primary objective of this research is to design an expert system to provide first aid in an ambulance and to teach the principles of first aid. Knowledge-based diagnostic systems are integral to the healthcare system, assisting paramedical staff, medical professionals, and patients in the diagnosis and treatment of diseases and medical emergencies. For novice doctors, an expert system can be particularly beneficial in mitigating challenges due to inexperience. The draw.io program was utilized to create a planned system, as illustrated in Figure 1.

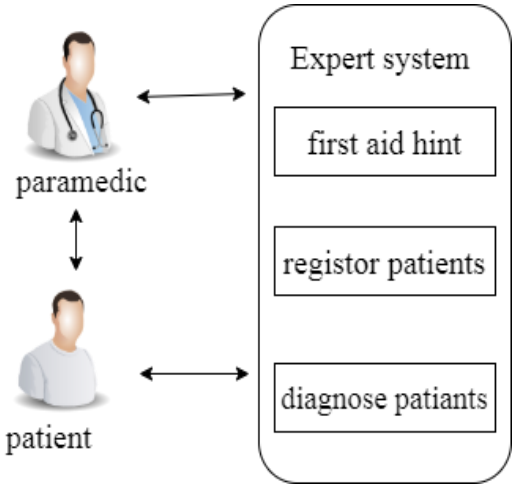

Figure 1: The relationship of the expert system, the paramedic, and the patient.

The system functions as a mentor or guide for paramedics, helping them determine the necessary procedures for patient care and avoiding common medical errors. From the moment the patient is reached, the system collects data about the patient's condition, including general health, medical history, vital signs, and specific diseases. These programs, processes, and regulations, along with the accompanying documentation, are stored in read/write memory. The prototype of the expert system is programmed using the SWI-Prolog language to represent expert knowledge, and the XPCE tool within SWI-Prolog is used to create a graphical interface with complementary libraries that facilitate user interaction.

Design of the Medical Expert System in an Ambulance

The system is divided into two parts:

1. First aid procedures
2. Learning first aid

Expert Systems Development Stages

1. **Problem Definition**: This stage involves clearly defining the problem, the nature of the inputs, outputs, and objectives to be achieved. It also identifies the end user and the field expert collaborating in building the system.
    - The problem addressed by the expert system in the ambulance is providing medical advice to properly treat patients.
    - System inputs are answers to questions posed to the paramedic about the patient's general condition, history, vital signs, and symptoms.
    - System outputs include medical instructions and first aid procedures, as well as a report on the patient's condition, which is sent to a hospital for the doctor's review.
    - The end users of the expert system are the medical staff or paramedics in the ambulance who perform first aid based on the system's directions.
    - Field expertise is provided by a specialist doctor experienced in emergency medicine.
2. **System Design**: This stage defines the relationships between the system's components and their interactions to solve the problem. It demonstrates how information is derived from the expert (the emergency medicine doctor). In the ambulance process, the expert identifies the patient's complaint or injury location, monitors vital signs, and takes appropriate measures to provide necessary aid. The draw.io program is used to illustrate the method for recognizing medical complaints.

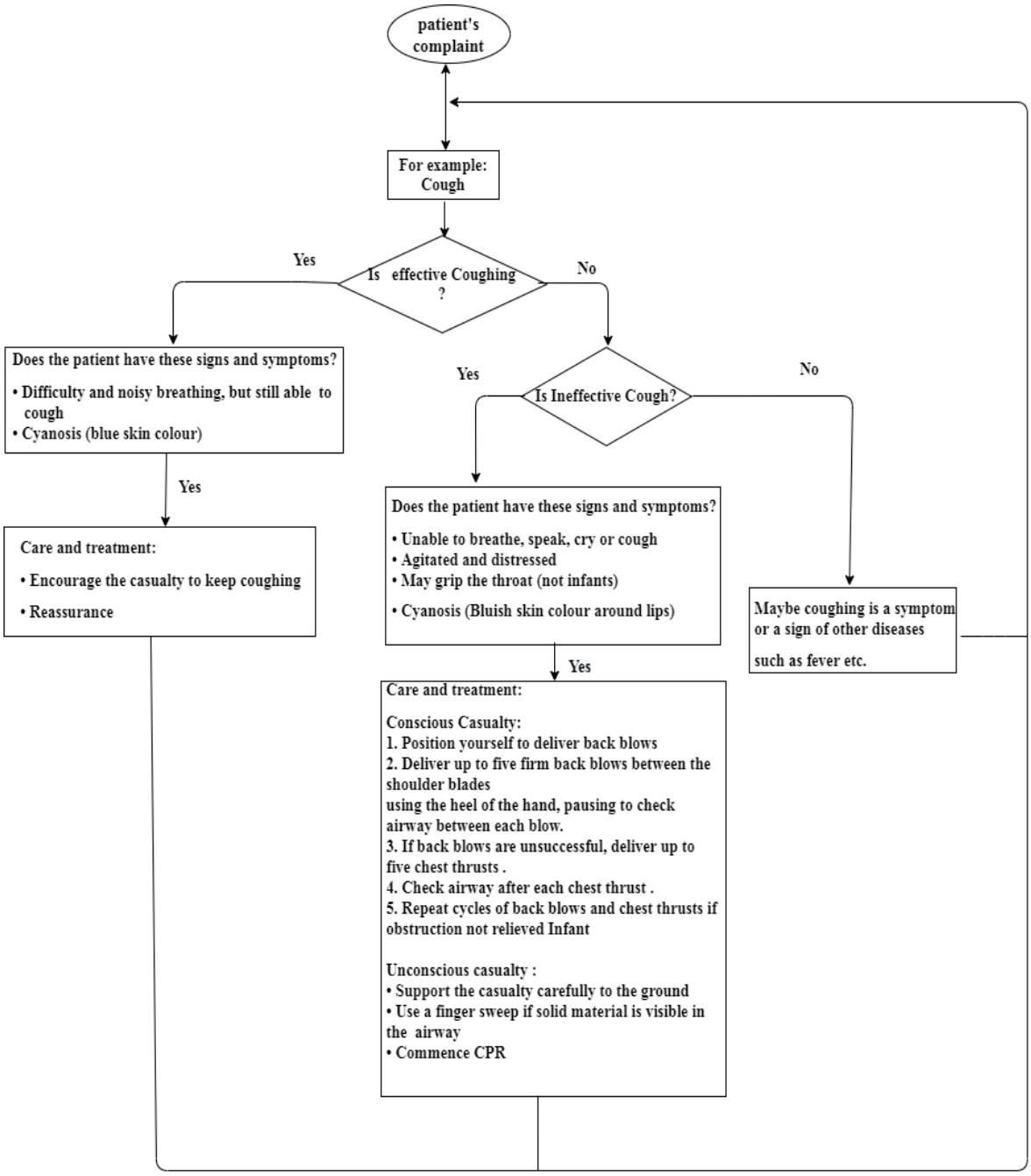

Figure 2: The method for recognizing the complaint of a medical state.

Formalization Stage

During the formalization stage, the logical design process of the expert system is undertaken. Information is typically organized into tree structures. The draw.io program is employed to create a planned diagram that illustrates the logical sequence of the system's operations from inception to achieving its objectives. In the data hierarchy, knowledge identification and representation are utilized. The flowchart derived from emergency medical guidelines and services aids in the diagnosis and care of patients. The draw.io program is used to generate a planned diagram, as shown in Figure 3, depicting the logical sequence of the system.

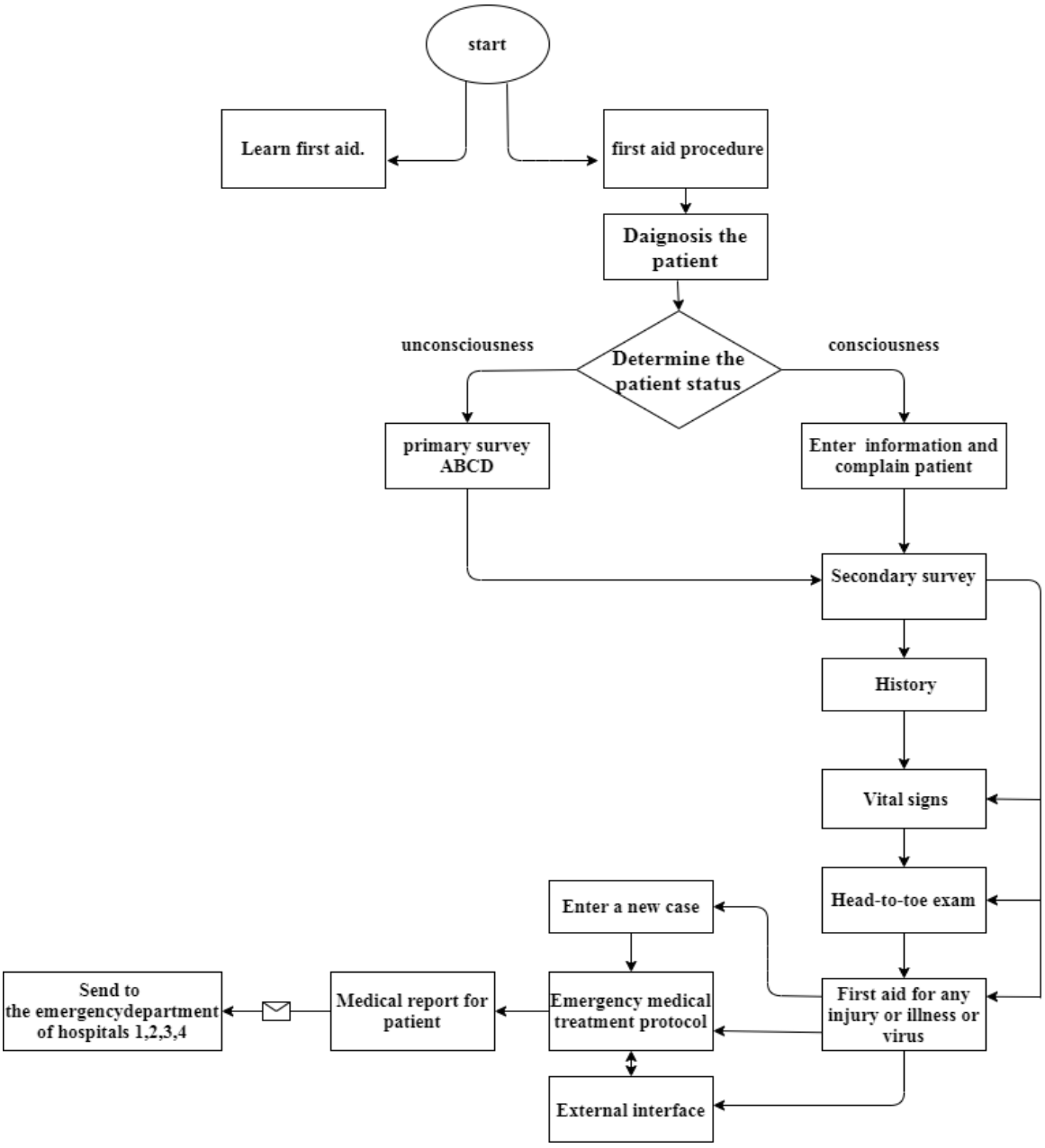

Figure 3: The logical sequence of the system/

System Implementation

The final stage in the development of the system is the implementation phase, which focuses on the design of the system interface. During this stage, data is input into the expert system, and upon entry, the system generates a report detailing the necessary emergency measures.

System Validation

The validation phase involves evaluating the system's performance and making necessary revisions to ensure its accuracy and effectiveness.

Structure of Expert Systems

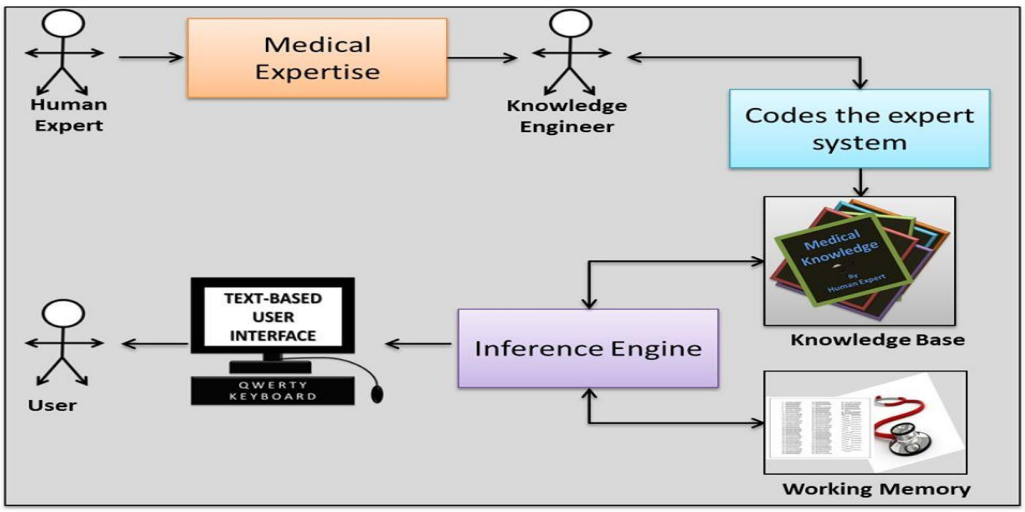

Figure 4: Key components of expert systems.

1. **Knowledge Base**: This component comprises the foundational information for the field of study, sourced from a domain expert, specifically a doctor. It includes essential medical data required for the expert system's operation, derived from an emergency medicine specialist following first aid treatment protocols. The medical knowledge encompasses complaints, symptoms, diseases, and their treatments.
2. **Inference Engine**: The primary function of the Inference Engine is to perform reasoning by linking rules to facts and deriving new facts.
3. **User Interface**: The User Interface enables interaction between the user and the expert system. It is responsible for receiving input and presenting the final output, which is a report detailing the necessary emergency measures.

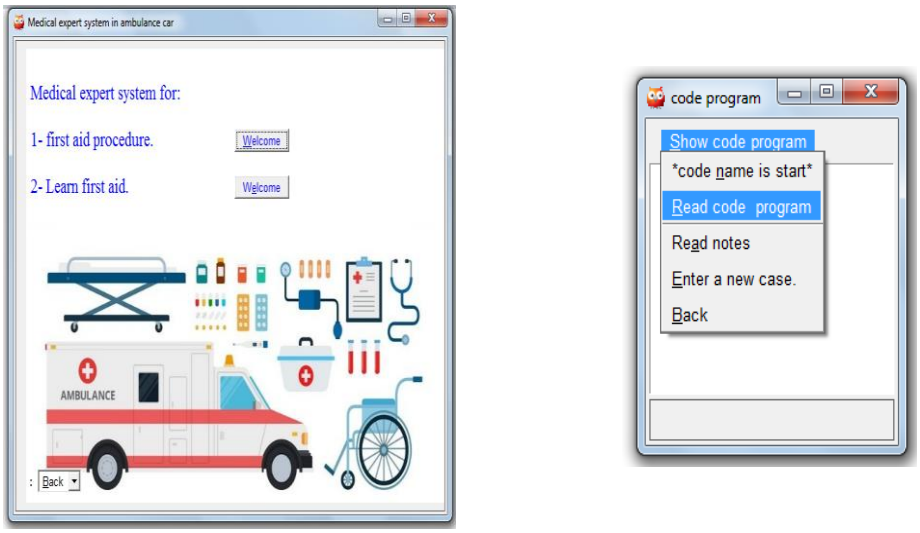

Figure 6: First section is the medical expert system and the second section is the program code.

4. **Explanation Module**: This module allows the user to inquire how the expert system arrived at a particular conclusion and why specific information is required.
5. **Developer Interface**: This interface is utilized by developers to update and modify the knowledge base.
6. **Main Screen of the Program**: This interface is divided into two sections:
    - The medical expert system
    - The external program (code program)

In figure7, the system consists of Diagnosis (diagnosis of the patient).

Figure 7: The patient diagnosis.

Figure 8 is composed of two sections:

- **Assessment of Patient Status**: This section determines whether the patient is conscious or unconscious.
- **Patient Medical Report**: This section provides a detailed medical report for the patient.

Figure 8: Determine the patient's status and provide a medical report for the patient.

Conclusion

The proposed model significantly enhances the accuracy of medical diagnoses by effectively identifying pathological conditions. Implementing expert systems is particularly beneficial in rural areas with limited access to medical professionals, acting as a catalyst for improved healthcare performance. A key recommendation for future research is to expand and develop the knowledge base to encompass all known diseases globally. Additionally, it is advisable to develop this system into a smartphone application, enabling patients to use it in the absence of a doctor.

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