https://doi.org/10.57223/spies.2023.1.1.03

Agnieszka Woehl[1)], Kacper Zapotoczny[1)], Julia Żaba[1)], dr inż. Łukasz Nagi[2)]
[1)]Opole University of Technology, Department of Computer Science, Prószkowska 76, 45-758 Opole
[2)]Opole University of Technology, Department of Electricity and renewable energy, Prószkowska 76, 45-758 Opole

Application of sample advisory systems in medicine

KEYWORDS

advisory system, expert system, block diagram, decision tree

ABSTRACT

Artificial intelligence is a field that has been rapidly developing in various areas of knowledge in recent years. Its application in medicine can support the intensive development of research in health care and improve and accelerate the operation of many medical facilities. This article presents several examples of expert systems that can find application in diagnosing and preparing a patient for selected tests. Expert systems can also find application in the rapid selection of rehabilitation, medical or support equipment and devices with which medical facilities are supplied. In this article, the reader will also find a sample application that will perform this function. The article presents the elements of which a correct expert system should consist. For each application, tests have been carried out to show the correctness of the system. The purpose of the article was to show the capabilities of the expert system and its application in medical fields.

1. Introduction

The origins of expert systems date back to 1956. The individuals credited with initiating the computer programs are John McCarthy, Allen Newell and Herbert Simon. At a working conference in Dartmouth, they presented the first expert program, which is still in use today. Such a system performs analysis just like a human being, which gives it the name artificial intelligence [1].

1.1. The concept of an expert system

An expert system is otherwise known as an expert system or an advisory system. It is a concept in the field of artificial intelligence. It is a computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require the knowledge of experts in a particular field. Expert systems solve complex problems based on the analysis of a knowledge base and consist of a program that allows the user to ask questions and seek answers to previously asked questions, and a database from which answers are provided.

1.2. Outline of the expert system

The expert system consists of several important subsystems. One of them is the knowledge acquisition module, which involves storing acquired knowledge in the knowledge base in the form of rules and facts. Another module is the inference module, which are various commands, procedures and programs. They combine facts with rules to formulate the user's answer. The explanatory module is software for interpreting the results obtained. It is optional because it is not used in every advisory system [2, 3]. The outline and structure of the system is shown in Figure 1.

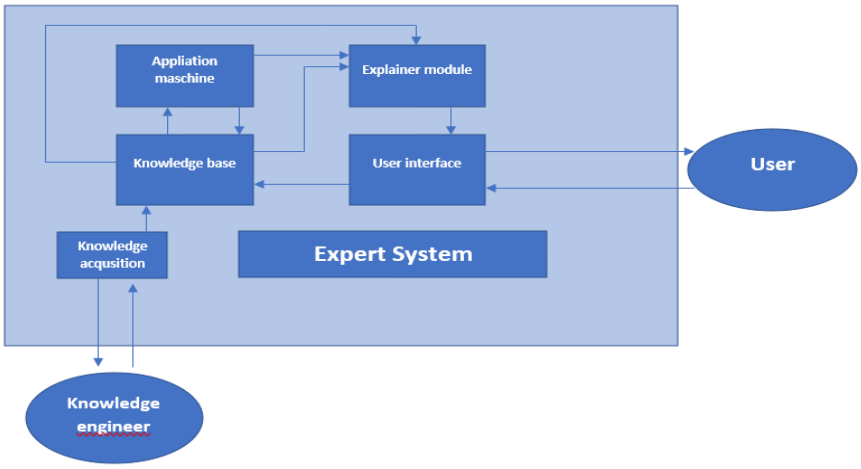

Fig. 1. Construction of the expert system *[Source: Own elaboration]*

1.3. Block diagram

The term block diagram is used to describe a diagram by which a given algorithm is represented by means of certain geometric figures, which are connected by lines according to the order of execution of successive steps in the algorithm. With the help of a block diagram, it is possible to accurately analyze the steps in the proceedings of an algorithm and detect the logical relationships between the steps. Thanks to the use of the block diagram, there is a simple conversion of instructions into a record of a computer program using the chosen programming language. The block diagram of the sample expert system was created using the yEd Graph Editor program. The block diagrams of the author's expert systems are presented below (Figures 2 and 3) [4].

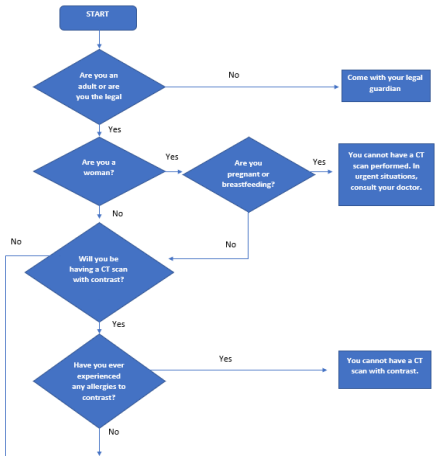

Fig. 2. Excerpt from the block diagram of expert system for initial patient diagnosis for CT examination *[Source: Own development]*

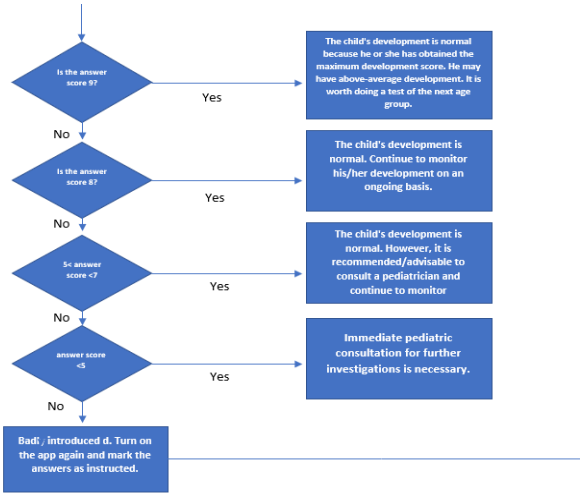

Fig. 3. Excerpt from the block diagram of the system for diagnosing sensorimotor development of a child aged 0–3 years *[Source: Own development]*

1.4. Decision tree

A decision tree is a graphical decision support method used in decision theory. The task of decision trees can bé both to create a plan and to solve a decision problem. A decision tree has been used as a structure for a wheelchair selection support program. This form of decision support seems most suitable for the knowledge base that is found in the expert advisory system. [5]. The decision tree of the wheelchair advisory system was also made in the y Ed Graph program and is shown in Figure 4.

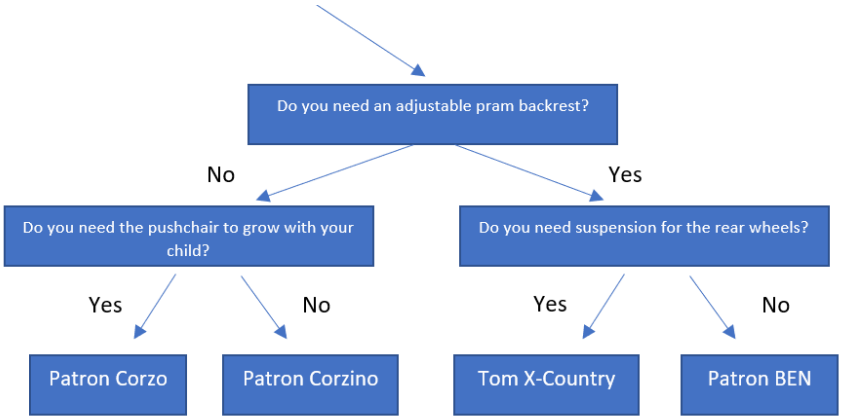

Fig. 4. Excerpt from the decision trees of the expert advisory system for wheelchair selection *[Source: Own development]*

1.5. Programming language

All applications were written in C++ using Microsoft Visual Studio from Microsoft. Microsoft Visual Studio is a program, found in the development of various types of applications or programs. The C++ language is the most widely used programming language because of its intuitiveness. In the programs were used *if* and *else if* functions which are commonly used in C++ language. These functions are dependent on each other because after calling the *if function* and assigning arguments to it, we can negate it, i.e., put the opposite value to the *else if,* thus making the argument must be opposite and a different value can be assigned to it. One program uses a multiple *switch* statement. Each *case* is assigned a value accordingly. The variable is executed until the *break* statement is reached [6, 7].

1.6. Database

A knowledge base is defined as knowledge that is stored in the system by means of facts or rules [8]. The example knowledge base for an expert system for the initial diagnosis of a patient for a CT scan was created independently, due to the lack of official data provided by medical units. The knowledge base for this application consists of 15 potential patients who vary in gender, age, medical conditions and the type of examination being performed. It shows the program's behavior with a sample individual.

The database in the system for diagnosing a child's sensorimotor development from birth to age 3 consists of seven groups created according to age. For each group, the database includes questions and possible cases of diagnoses that are possible. It is worth noting that the database for each group differs in the questions that are asked under a specific age group from five different categories: large motor, small motor, cognitive functions, social functions and speech.

The database in the expert system for advising on wheelchair selection includes used wheelchairs available from online stores: gtmmobil and mobilex. These stores offer to buy sports wheelchairs, children's wheelchairs, basic everyday wheelchairs and electric wheelchairs [9, 10].

3. Examples of advisory systems in medicine

Expert systems were developed for three areas from medicine and are presented below.

3.1. Use of expert system for initial patient diagnosis for CT examination

Medical imaging by CT scanning is based on X-ray images of the subject's organs, taken in various planes by a dedicated scanner [11]. How to prepare for a CT scan depends on what areas of the body will be imaged. Pregnancy and breastfeeding preclude the CT scan [12]. Medical conditions such as kidney disease, thyroid disease and allergies to the shading agent require specialized testing before CT. CT scans can be performed with or without the use of contrast, anesthesia, or anesthesia. [13].

3.1.1. The purpose of creating the application

The idea of an app for preparing a patient for a CT scan was born with the idea of relieving medical personnel of the duty to provide consultations in this regard. This will provide the patient with all the information on the procedures performed before the CT examination. The questions included in the program are based on commonly available knowledge.

3.1.2. Operation and test of the application

The application works in several stages. The first step involves verification of basic information, such as gender or age. Next, a choice is made as to whether the CT examination will be performed with contrast or under anesthesia. After selecting a given option, verification of the patient's medical conditions takes place, which may exclude him or her from performing the examination with an additional agent. In the next stage we proceed to the selection of the type of examination. After the appropriate selection of the right one, a check is made to see if the user has performed all the steps that are necessary before performing a CT examination. If we do not select any in the given options, the system will terminate the program. In this application, we answer with 0 and 1, which in turn correspond to the answer to the question "YES" or "NO". In addition to the questions that verify the preparation for the CT examination, the program displays messages to be included in the examination.

The application was made available to one person to test the correct operation. She is a female adult, not pregnant and not breastfeeding. The subject has no history of allergic reactions to contrast agents or acute sensitization reactions to other substances. The test will be performed using contrast without anesthetic anesthesia. The test subject has no medical conditions such as kidney disease, thyroid disease and diabetes. All test results were correct. The test person does not smoke cigarettes and does not have an emergent stoma. The selection of a CT scan of the abdomen and small pelvis was followed by verification that all pre-test activities had been performed. The program ended, due to the fact that the test subject emptied her bladder immediately before the examination, which she should not have done. At the end, a message was displayed about what to do in such a situation. The program worked correctly.

3.2. Application of expert system for sensorimotor development of children from birth to 3 years of age

Observation of a child's development is important for early identification and treatment of developmental disorders. However, examination in the doctor's office is often stressful for the child, and it is difficult to assess transparently whether the child is developing according to the percentile grid. It is also important to remember that a young child in the doctor's office can sometimes be restless and mobile. In order to streamline the examination, a diagnostic system for the child's sensorimotor development may be a better solution to quickly conduct the examination.

3.2.1. Types of child development

Child development is a very complex topic. It can be considered in 5 basic levels. These are large and small motoric, communication, cognitive functions and social-emotional functions. Large motility represents all movements in which the child's whole body or a large part of it is involved. There is a wide range of activity from laying down in the earliest stages through sitting, walking, jumping, to dancing or riding a bicycle. Small motor skills are precision movements, which mainly refer to hand and finger movements that require a lot of focus and concentration. Communication includes speech, tongue movements and non-verbal communication through various types of gestures. The cognitive area is cognition and refers to higher mental activities. These include the ability to perceive, process and remember information. The social-emotional area is the social, emotional and behavioral skills of a child's broad range of mental development [17–22].

3.2.2. Description and role of the expert system for diagnosing child development

A diagnostic system for the sensorimotor development of the child from birth to 3 years of age would certainly improve the study. It is based on concrete facts and was created on the basis of scientific articles and books, our own knowledge of the issue and the knowledge of an expert midwife from the Center for Gynecology, Obstetrics and Neonatology in Opole. The architecture of the system is multilayered and based on the age group of children 0–3 years. The diagnostic system consists of a series of questions. The questions were formulated on the basis of books and scientific articles, partly on the basis of our own experience and mainly based on the knowledge of a midwife from the Center for Gynecology, Obstetrics and Neonatology in Opole, who is engaged in diagnosing the psychophysical development of children. The diagnostic system is based on bivariate (Boolean) logic. The system gives a series of questions depending on the age group, and the user answers yes (1) or no (0) to these questions. Finally, a diagnosis is displayed, which the system gives after adding up the specific answers.

3.2.3. Description and performance test of the application

Initially, the application displays a welcome message. Next, the user enters the child's age in months according to the displayed query. The next step is for the user to answer questions tailored to the child's age group according to the instructions. Finally, a diagnosis is made by the system that is adequate to the user's answers to the questions asked. The result is obtained by adding up the affirmative answers. For children up to 12 months of age, the application is designed to monitor whether the child is developing properly or whether pediatric consultation is necessary/recommended. For children older than 12 months, the system additionally checks for movement disorders, cognitive and socio-emotional disorders, and speech disorders. The system also then determines whether consultation with an orthopedist or physiotherapist, psychologist and speech therapist are necessary, depending on the results. The test can also be performed several times without the option to turn off the program.

A system for diagnosing the sensorimotor development of a child aged 0–3 years was made by several caregivers of children of different age groups to perform a test and check the correctness of the program. The user answered questions from the 9–12-month age group. The user answered virtually all questions in the affirmative. It was concluded that the child's development was normal and should continue to be monitored.

3.3. Use of expert advisory system in wheelchair selection

The emotions that accompany the purchase of a wheelchair are enormous, as it is, for some, an investment that translates into better health, comfort and greater independence for the user. The doctor has the option of writing a card for the simplest and least functional wheelchair among the three on the NHF reimbursement list [23]. It is important at the outset that a person with a disability is equipped with a wheelchair that is properly suited to his needs [20]. On the market we can find various types of wheelchairs differing in the type of propulsion system, the method of use, the target group and many other features important for people who move on them

We can divide wheelchairs into several types: classic, electric, sports and children's wheelchairs.

3.3.2. Purpose of creating the application

The purpose of creating a simple wheelchair advisory system was to help people struggling with the sometimes-lifelong decision of buying a wheelchair. The system, with the help of the user's YES or NO answers, tries to select a wheelchair suitable for the choices and requirements made from the available database. The program starts with the question, "Are you an adult?", which is the apex of the decision tree. If the value entered by the user is equal to 0 (which means "no"), the program will display the next question from the tree regarding mobility in relation to the disability you have. The generation of answers by the program is based on the answer given and the implemented scheme of the previously created decision tree.

3.3.3. Operation and test of the application

A sample test of a program simulating the selection of a suitable wheelchair was performed. The test consisted of selecting a youth wheelchair for a child who is able to move independently in a wheelchair, is more than 3 years old and weighs more than 50 kg. In the end, it gave a suggestion for a GTM Junior wheelchair.

4. Conclusions

The purpose of the article was to demonstrate the capabilities of an expert system and its application in medical fields. The goal has been achieved, and the completed project has allowed us to expand our knowledge of expert system issues and apply it to proprietary applications developed in Microsoft Visual Studio in C++. The applications fulfill the most important functions and are in line with the current state of medical knowledge. Artificial intelligence and modern technologies are already increasingly becoming an integral part of the health care system. They can support doctors and diagnosticians when making a diagnosis and choosing a treatment for a patient. It is worth creating new intelligent solutions now, as information systems are now one of the key support tools for modern medicine. It should be remembered that artificial intelligence in medicine is still in the development stages. However, its great advantages are an incentive to expand and improve it.

References

[1.] Wilińska M. *Expert systems*. Issues of Scientific Information **2010**, *1*, 3–40.
[2.] Kieltyka L. *The use of expert systems in knowledge management*; Łódź, 2013.
[3.] Expert system – Encyclopedia of Management Available at: https://mfiles.pl/pl/index.php/System_ekspercki (accessed October 29, 2021).

[4.] ISO 5807:1985 – Information processing – Documentation symbols and conventions for data, program and system flowcharts, program network charts and system resources charts Available at: https://www.iso.org/standard/11955.html (accessed November 1, 2021).
[5.] Decision tree - Inguaris. Accessed December 2, 2021. https://www.inguaris.pl/teoria/drzewo-decyzyjne/
[6.] Visual Studio Available at: https://visualstudio.microsoft.com/pl/ (accessed November 14, 2021).
[7.] C++ Available at: https://isocpp.org/ (accessed November 14, 2021).
[8.] Simon A., Shaffer S. *Data warehouses and business information systems*.
[9.] sports wheelchairs – GTM Mobil. Accessed December 2, 2021 http://www.gtmmobil.com.pl/oferta/sportowe/
[10.] wheelchairs in the largest selection " Mobilex. Accessed December 2,2021 https://www.mobilex.pl/produkty/wozki-inwalidzkie/
[11.] computed tomography – what the study is about – About imaging studies | Research blog Famous Doctor. Accessed November 8, 2021. https://badania.znanylekarz.pl/blog/tomografia-komputerowa-na-czym-polega-badanie/
[12.] preparation and contraindications for CT examinations – SCANiX. Accessed November 8, 2021. http://www.scanix.pl/tomografia-komputerowa/przygotowanie-do-badan-tk/
[13.] preparing for computed tomography | iMed24.co.uk Krakow. Accessed November 8, 2021. https://imed24.pl/poradnik-pacjenta/przygotowanie-do-badan/przygotowanie-do-badan-radiologicznych/przygotowanie-do-tomografii-komputerowej/
[14.] Dosman C., Andrews D., Goulden K. *Evidence-based milestone ages as a framework for developmental surveillance*. Paediatrics & Child Health **2012**, *17*, 561–568.
[15.] Bee H. *Psychology of human development*.
[16.] Czub M. *Child Development Early Childhood*; ISBN 9788361693505.
[17.] Strelau Jan *Psychology Academic Handbook Volume I*; Gdańsk, 2000; ISBN 8387957064.
[18.] Rogers C.R., Nulty K.L., Betancourt M.A., DeThorne L.S. *Causal effects on child language development: A review of studies in communication sciences and disorders*. Journal of Communication Disorders **2015**, *57*, 3–15, doi: 10.1016/J.JCOMDIS.2015.06.004.
[19.] Wang Z., Wang L. *Cognitive Development: Child Education*. International Encyclopedia of the Social & Behavioral Sciences: Second Edition **2015**, 38–42, doi:10.1016/B978-0-08-097086-8.92007-5.
[20.] wheelchairs – niepelnosprawni.pl. Accessed December 2, 2021. http://www.niepelnosprawni.pl/ledge/x/203731