The project of implementing the expert system to analyse polyp changes in the alimentary canal

Dariusz Gutek[*]

Institute of Computer Science, Faculty of Electrical Engineering and Information Technology, Lublin University of Technology, Nadbystrzycka 36B, 20-618 Lublin, Poland

Abstract

The following article presents the theoretical way of implementing the expert system which, due to the co-operation of the system with the person conducting the endoscope examination, will enable the medical staff to qualify and classify the observed pathological changes in a quicker manner.

1. Introduction

In the works researching pathological changes of the human alimentary canal, especially the polyps and similar ones, we may frequently observe that the volume and diameter of polyps in some cases provide different information about the treatment method from that in others. Apart from the size of the polyp, one should also consider its shape, location in the alimentary canal, texture, porosity, and the colour of the integument as well as the depth of the polyp rooting in the alimentary canal walls.

All these qualities of the pathological change store such information that, after having a closer look at it, one may consider the possibility of characterising the pathology. On the basis of this, we may try to build the system that, firmly established in the rules of the expert system, would describe and inform the user that the analysed case can undergo medical treatment and suggest some procedures of doing it. Such a system could also inform us that the observed case does not necessarily have to be a pathological change and it would classify the image as a case which requires closer examination in order to be recognised correctly.

The application of rules resulting from the properties of the expert system operation seems to be an appropriate approach to deal with the phenomenon of

---

[*] *E-mail address*: darekg@pluton.pol.lublin.pl

polyp changes. The suitability of such an application is unquestionable also due to the types of measure errors which may occur during the medical examination.

2. AIM

The aim of this paper is to examine the possibility of creating the research post in the form of the expert system. On the basis of the information input, the system would be able to classify the given case as morbid and, if so, how far advanced it is. The system would also suggest the possibilities of medical treatment depending on how advanced the pathological changes are.

3. Materials and methods

It is becoming more and more desired to support the process of decision making in medicine because of the rapid technological development and information input which doctors are exposed to when they examine their patient's condition. The problem may arise when one has to analyse the data coming from various medical examinations and test results. A computer system supporting the process of decision making may turn out beneficial in this case. Such systems are able, for instance, to use the data from the archives to search for the most important information in a short time. They also show deviations from the correct values and suggest the diagnosis and the possible ways of treatment. The systems can also instantly compare the latest test results with the archival ones and, on the basis of such comparison, can make a statement about either improvement or worsening of patient's condition.

One should also bear in mind the complexity of the decision making process, especially as it is connected with medical treatment, application of drugs and other clinical decisions.

There is a wide range of techniques that can be used when developing a clinical decision support system. Among them one can distinguish the clinical algorithm, the expert systems based on rule knowledge, neural networks, fuzzy logic systems, systems based on rough set theory, systems based on conditional probability and others [1]

Clinical algorithms are currently the most common system used in hospitals and clinics. These algorithms describe the list of successive activities that are to be done by the person who conducts the medical examination or minor operation. At the same time they are one of the simplest tools supporting the work of medical staff.

The aims of the use of clinical algorithms are mostly the following:
- decrease in the number of deviations from the correct pattern of clinical conduct,
- reminding of the successive activities in patient's care,
- similar intensity of medical care for all the sick,

– a sort of assistance during the court trials because acting according to the established rules protects you from criminal responsibility.

There exists a convenient method of recording the algorithms, the so-called, action network which, in a very logical and transparent way, presents the sequence of undertaken actions.

The project that is being worked out assumes the creation of such a system in which the databases will be supplemented with the data received from the procedure being in agreement with the presumed algorithms. Such procedure will make it possible to get an exact repeatability of the test results of the consecutive patients. It will also enable us to compare the current test results with the archival ones.

The expert system is characterised by the following features:
– all the information from the field of knowledge we are interested in is registered in a formalised and well-ordered structure called a database,
– the processing of information from the database is achieved with the help of an especially constructed part of the program that is called an inference engine,
– the system is equipped with the mechanism which allows to communicate with the user and it is called user interface.

There are numerous advantages of using the expert system, mostly an easy access to information and the combination of various experts' knowledge. In this case it is also necessary to add some computational models to the system which provide quantitative information about the examined phenomenon very quickly. The possibility of continuous update in the database as well as the reduction in the costs of the expertise are the other valuable properties of the system.

In the expert systems we use most commonly the symbolic notation of knowledge in the form of statements, rules, semantic nets, frames and the modules of knowledge:
– statements – well-ordered triples: <object> <attribute> <value> [<*cf*>] where [<*cf*>]_represents the so called "certainty rate" i.e. the number describing to what extent one can be sure about the legitimacy of a statement (in this case the rules of fuzzy logic must be used),
– rule – an easy-to-understand way of recording knowledge; it has the following structure: if /condition/ then /statement/; "action" can mean either drawing a conclusion or undertaking an operation,
– semantic nets – human memory mapping represented by a graph in which nods stand for the statements, notions or objects; the vertices of a graph represent the relations between them,
– frames and the modules of knowledge – an extension of the recording of knowledge by means of the triples: <object> <attribute> <value>.

In the system that is being constructed one should also consider the possibility if introducing some changes in the future. These changes should

especially refer to the system responses when some new information about the patient's condition is introduced into it. What is meant is the situation when "the patient A has a pathological change B". After additional examination and tests, and when either some new supplementary data are introduced into the system or if there occur some other conditions (that have some influence on the conclusion i.e. "chaining" about an illness), then the system has to react with a statement like the following: "there is suspicion of a pathological change or disease C with a given patient."

Expert systems use most commonly two kinds of chaining (i.e. concluding): forward and backward chaining. Forward chaining (Fig. 1) is brought to an end when you cannot fire any of the rules or when the required conclusion has already been found.
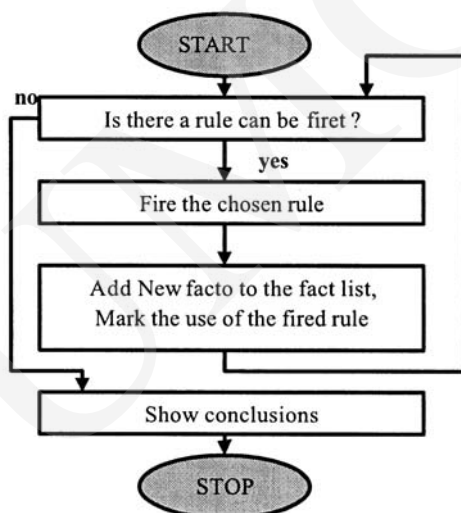

Fig. 1. The scheme of forward chaining

Backward chaining is based on doing the search of the rules the conclusions of which are known by the inference engine programme. These conclusions can be either true or false, or they can also be hypothetical and their genuineness needs to be indicated. On the basis of the genuineness of the conclusions one can subsequently conclude about the genuineness of the premises of the rules.

The obvious advantage of such a way of knowledge recording is huge transparency and ease to understand. However, in a knowledge base of this kind there can also appear certain problems, for instance:

– contradictory rules – the rules in which conditional parts are identical but the conclusions are exclusive, e.g. *if A then B* and *if A then not B,*
– repeating rules,

    – the looping of the rules – the rules activate one another in an endless loop as a result of the incorrect formatting of the conditional parts.

4. Research post

During the research we gain certain knowledge about the shape and the colour of the integument of the polyps at the time of endoscopic examination or from the film that has been recorded. Such a film is closely investigated by both the equipment operator and the monitoring software. During the investigation all the irregularities are initially described and classified as deviations. All the examinations conducted so far have been done by an expert – a qualified doctor who has been estimating the patient's condition. It has been his knowledge that could verify the images appearing on the computer screen.

In this paper I attempt to specify the possibilities of creating the software that could support a doctor as an expert. Furthermore, I would like to investigate whether it is likely to create such an expert system from which the software could derive certain knowledge and compare it to the currently examined picture. The system would be also equipped with the function of independent estimation of a pathological change, and the conclusions would be finally verified by an autonomous expert.

Having considered the problem, it seems that the use of methods of fuzzy logic is the most appropriate here as it could bring the majority of advantages at the shortest possible time. The expert system created on the databases would enable us to select and compare given information very quickly. We could effortlessly verify all the final results of examinations or expertise because of storing them in databases. At the time of receiving additional information, coming from the examination of the same pathological changes but by means of different methods, the system could question the truthfulness of the facts that were established earlier. This way of storing the data would also enable us to record the results of the following examinations in a simple way as well as to compare various examination results for a chosen patient. It would also be possible, due to the instant comparison of the pictures gained at different periods of time, to observe how the given anomaly has been behaving, which may considerably influence the decisions taken in the further course of events.

However, when creating such an expert system one needs to remember that the data stored there, before they are introduced into the system, must be defined: unambiguously – by the colour definition; invariably – by, for instance, mathematical function describing the shape of the integument or its regularity, or by a definite quantity, for example, the polyp diameter or its volume (Fig.2).
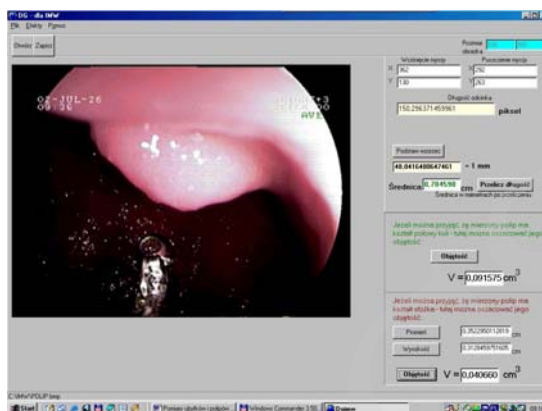
Fig. 2. The program that is able to define the diameter of a polyp

When one notices the differences in various shapes of the polyps (Figs. 3-7), it becomes obvious how many dependencies need to be stored in the database in order to have a complete picture reflecting the pathological change.
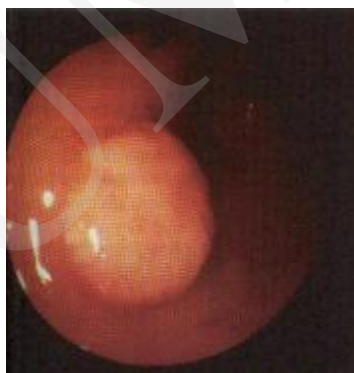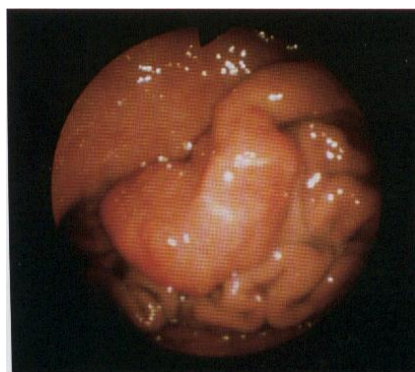

Fig. 3. A regular-shaped polyp
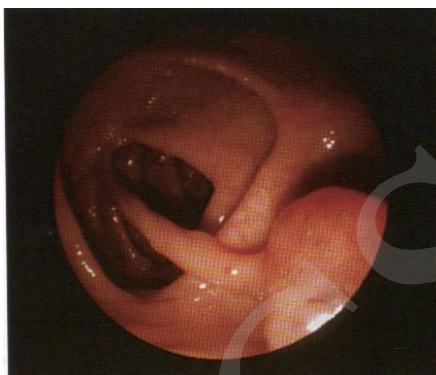

Fig. 4. Hyperplastic polyp
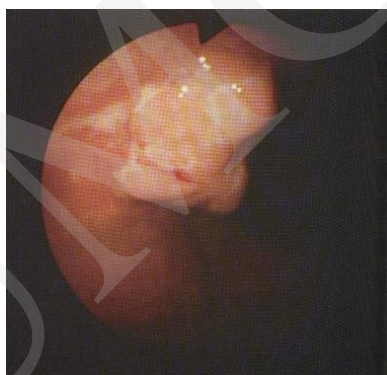
Fig. 5. A polyp with a very long pedicle

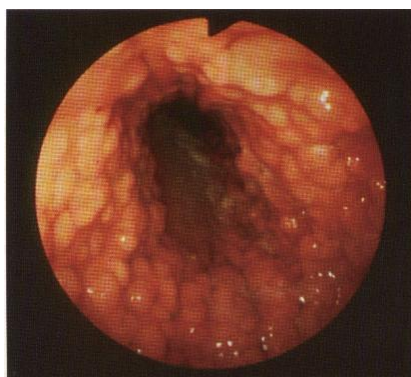Fig. 6. The metastasis of mamilla cancer into the stomach

Fig.7. Polyp "carpet"

On the basis of the observations that were made it seems that one needs to store the following information about polyps in databases: the spot of polyp occurrence (description or list box with the parts of the alimentary canal), polyp

height (mm), its diameter (mm), volume (cm^2), the length of the pedicle (mm), colour (list of values or colour template), haemorrhage (yes-no check box), shape regularity (list of values), introductory classification of cancer type (medical term if the polyp resembles one of the well-known cancer diseases), the depth of polyp rooting (mm – text field that is completed after an ultrasonographic examination showed such results), occurrence of ulceration (list box), blood supply (list box), and, finally, notes (text field).

The analysis of pathological changes leads to the creation of some exemplifying rules on which the designed system is based:

Rule 1:
If a polyp is of porous texture then it can be a cancer change.
Rule 2:
If a polyp diameter exceeds a certain size (recognised as extensive) then the polyp is suitable for polypectomy (excision).
Rule 3:
If a polyp is well blood-supplied then it should be excised in small portions.
Rule 4:
If a polyp has a distinct pedicle then it should undergo polypectomy.
Rule 5:
If a polyp is of a diminutive size and smooth texture then the fact of its occurrence should be notified in the database and left for further observation.

Apart from created rules which are mentioned above one also needs to create certain functions (based on the results of various endoscopic examinations and expert knowledge from written and human resources). These functions would define, on the strength of fuzzy logic, what diameter or volume of a polyp should be regarded as extensive and what curvature defines the porosity of polyp texture.

Obviously, the general patient's condition as well as his age should also be taken into consideration, as it may turn out that medical interference into the alimentary canal of a patient who is over 85 is futile.

5. Summary

The aim of this paper is to outline the shape of the expert system that is being developed and which, in the future, will be implemented in an endoscopic laboratory. The system, using the rules defined in the expert part, would qualify the advancement of pathological changes observed during the examination. The planned part of the system, that is responsible for concluding, should be supplemented with clear, non-exclusive rules.

Another question that is partly raised in the paper was noticed at hospital wards. It is the need of creating an application for storing the data about patients' health. Applications of this kind are remarkably needed to store not only the

personal data but also graphic files and films produced during examinations, which, unfortunately, is still quite rare.

References

[1] Dzieżak M., Grabowski M., Guć M. et al., *Informatyka medyczna*, PWN, Warszawa, (2003), in Polish.