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KNOWLEDGE TRANSFORMATION IN THE INTELLIGENT SYSTEM FOR HEPATOCELLULAR CARCINOMA STAGING

M.H. MAMMADOVA[1], N.Y. BAYRAMOV[2], Z.G. JABRAYILOVA[1], M.I. MANAFLI[1], M.R. HUSEYNOVA[2]

[1]Institute of Information Technology of ANAS, Baku, Azerbaijan
[2]Department of Surgical Diseases Azerbaijan Medical University, Baku, Azerbaijan
e-mail: mmg51@mail.ru, djabrailova_z@mail.ru

1. Introduction

One of the main tasks of a physician in modern medical practice is to appoint an accurate diagnosis, to prescribe the right treatment in multifactorial uncertainty [4]. Thus, the manifestation of many common diseases with weak and atypical symptoms, incompleteness and inaccuracy of information shifts the issues of diagnosis and the appointment of treatment into a fuzzy environment, causing the diagnostic errors [1]. In order to prevent such problems, the creation of intelligent systems based on the knowledge of experienced doctors-experts in support of diagnostic and treatment decisions has recently become a topical issue [2]. Although the traditional methodologies have been formed for the creation of decision support systems, there are still problems in the transformation of medical expert knowledge into artificial intelligence, as well as in the trial of the established systems to justify their importance, and turning them into a daily desktop tool. This article discusses the creation of an intelligent system to provide doctors with accurate information about the stage of the disease to select the diagnosis and treatment methods of hepatocellular carcinoma (HCC), and highlights the solution of problems of transformation of natural knowledge into artificial one.

2. Problem statement

HCC is rated the 5th-6th most common cancer and the third leading cause of death from cancer. HCC is found in about one million people worldwide every year [1, 2]. Determination of the stages of HCC is the most important issue for its diagnosis and treatment. Solution to this problem depends on the degree of spread of the tumor, the condition of the lymph nodes, the functional state of the liver, the general condition of the body, etc. Of course, each criterion is characterized by certain features. In the context of this abundance of information, the HCC staging according to different combinations of clinical signs according to specific schemes. In order to prevent medical errors that may occur due to the multiplicity and hierarchy of criteria forming these schemes, the large number of signs, their uncertainty and linguistic nature, [4] provides a conceptual model of the HCC staging system, describes the principles of system functioning and its structural scheme. One of the main components of the system is the knowledge base, and the formation of its rules requires the development of transformation mechanisms (rules) in accordance with the standard schemes of clinical conditions and critical situations.

3. Problem solution

According to the final classification, 5 input data are currently taken into account for HCC staging, namely [2]: 1) number of tumors; 2) size of tumors;3) vascular invasion; 4) lymph node; 5) presence of distant metastases [1].

Each examination is determined by different clinical signs (Table 1) [1].

Table 1. Examination data and their clinical signs.

Examination data	Clinical signs	Conditional expression
Number of tumors *(t1)*	single tumor	*t1a*
	multiple tumors	*t1b*
Size of tumors (t2)	2cm or less	*t2a*
	greater than 2cm	*t2b*
	Less than 5cm	*t2c*
	greater than 5cm	*t2d*
Vascular invasion *(t3)*	no vascular invasion	*t3a*
	vascular invasion presents	*t3b*
	invasion of large branches of the portal vein	*t3c*
	invasion of the hepatic vein	*t3d*
	invasion of nearby organs (except the gallbladder)	*t3e*
	perforation of the peritoneum	*t3f*
Lymph node (N)	lymph node is not identified	*Nx*
	no metastasis in lymph node	*N0*
	metastasis in lymph node presents	*N1*
Distant metastasis (M)	No distant metastasis	*M0*
	Distant metastasis presents	*M1*

The standard combination of the number and size of tumor and the possible clinical signs of vascular invasion is identified as the following 9 clinical conditions based on expert evaluation:

$$T =< T1a; T1b; T2a; T2b; T3; T4a; T4b; T4c; T4d >$$

Expert knowledge of these 9 clinical conditions, the following rules are formed by referring to Table 1 through the IF-THEN extract program of knowledge description:

R1. If ($t1$ is $t1a$) and($t2$ is $t2a$) and ($t3$ is $t3a$) then (T is $T1a$)

R2. If ($t1$ is $t1a$) and ($t2$ is $t2b$) and ($t3$ is $t3a$) then (T is $T1b$)

R3. If ($t1$ is $t1a$) and ($t2$ is $t2b$) and ($t3$ is $t3b$) then (T is $T2a$)

R4. If ($t1$ is $t1b$) and ($\forall$ t: $t2$ is $t2c$) then (T is $T2b$)

R5. If ($t1$ is $t1b$) and ($\exists$ t: $t2$ is $t2d$) then (T is $T3$)

R6. If (($t1$ is $t1a$) or ($t1$ is $t1b$)) and (($t2$ is $t2a$) or ($t2$ is $t2b$) or (t2 is t2c) or ($t2$ is $t2d$)) and ($t3$ is $t3c$) then (T is $T4a$)

R7. If ((t1 is t1a) or ($t1$ is $t1b$)) and (($t2$ is $t2a$) or ($t2$ is $t2b$) or ($t2$ is $t2c$) or ($t2$ is $t2d$)) and ($t3$ is t3d) then (T is $T4b$)

R8. If (($t1$ is $t1a$) or ($t1$ is $t1b$)) and (($t2$ is $t2a$) or ($t2$ is $t2b$) or ($t2$ is $t2c$) or ($t2$ is $t2d$)) and ($t3$ is $t3e$) then (T is $T4c$)

R9. If (($t1$ is $t1a$) or ($t1$ is $t1b$)) and (($t2$ is $t2a$) or ($t2$ is $t2b$) or ($t2$ is $t2c$) or ($t2$ is $t2d$)) and ($t3$ is t3f) then (T is $T4d$).

The next stage establishes the possible combinations of the determined clinical condition with the clinical signs of the other two examination data. These combinations are brought to the standard schemes correspondingly in accordance with the 7 stages of the HCC, and the rules are established by transforming them on a similar principle.

4. Intelligent system for the HCC staging

A decision support system is developed to prevent physician errors in determining the stage of HCC, and it is implemented on Delphi programming platform. The system consists of a database, a knowledge base, logical reasoning and interface units. The database stores input data for HCC staging and a complete list of their clinical signs, the current results of the patient's examination (examination data) in a single format. The system's knowledge base (KB) consists of IF-THEN extract rules for the knowledge description that defines the clinical condition and critical situation (HCC stage) according to standard combinations of different clinical signs. The logical reasoning mechanism generates a new fact based on the current input data (clinical signs of input data) received from the working memory. It is compared with the antecedent part of the rules in KB (schemes for HCC staging), and the factual rule is activated and the result is transmitted to the user as logical reasoning mechanism result. These processes are implemented in the interaction of the relevant modules of logical reasoning mechanism with KB. The interface block provides communication between the user (physician) and the systems, enables entering the patient's examination data (current symptoms) into the system, and delivers the results obtained in logical reasoning mechanism to the user.

During the trial phase of the system, the ease and adequacy of the input/output interface, the effectiveness of the control strategy, the quality of the trial samples and their adequacy to reality were tested.

5. Conclusion

HCC staging system, like all other PDSSs, increases access to scientific facts, clinical recommendations, knowledge and expert knowledge related to the disease. The accumulation of expert knowledge on typical and atypical situations in these systems ensures its (knowledge) permanence, and prevents the loss of knowledge arisen in connection with the physician's physical, psychological, moral, etc. condition. The use of the system as a desktop tool by specialists in the relevant field enables physicians to eliminate errors in HCC staging, and to reduce the time spent on this process. The system development principles can be used for staging of other oncological diseases.

Keywords: Stages of Hepatocellular Carcinoma, Intelligent System, Clinical Conditions, Knowledge Base, Decision-Making.

AMS Subject Classification: 68M14, 68T30, 93C41, 93C62.

References

[1] Bayramov N.Y., In book: *Surgical Diseases of the Liver*, Baku, GQismet, 2012.

[2] Calderaro J., Seraphin T.P., Luedde T., Simon T.G., Artificial intelligence for the prevention and clinical management of hepatocellular carcinoma, *Journal of Hepatology*, Vol.76, 2022, pp.1348-1361.

[3] Mammadova M.G., Bayramov N.Y., Jabrayilova Z.G., Manafli M.I., Huseynova M.R., Principles for the development of an intelligent hepatocellular carcinoma staging system, *Problems of Information Technology*, Vol.11, No.1, 2021, pp.3-14.

[4] Mammadova M.H., Jabrayilova Z G., In book: *Electronic Medicine: Formation and Scientific-Theoretical Problems*, Baku, Information Technologies, 2019.