ADAPTIVE EXPERT SYSTEM FOR DYNAMIC BIOLOGICAL OBJECTS CONTROL AS APPLIED TO EPILEPSY TREATMENT

A. Lorchenkov
Technical University of Moldova

INTRODUCTION

In clinical practice pharmacotherapy is the most used method for epilepsy treatment. The goal of epilepsy curing is to prevent further seizures, avoiding side effects, and make it possible for people to lead common lives. In determining whether to treat [1, 2], physicians consider the risk-benefit ratio, which varies according to the activity level. Antiepileptic drugs have side effects and in some cases include liver damage and potentially fatal rashes and blood disorders. Thus the decision to cure becomes a highly individualized one in which the risks of the treatment are weighed against the risks of the seizures [1]. That's why it is important to analyze all factors: abnormal EEG, previous seizure, person drives and other neurological impairment. Review of relevant literature suggests at least seven distinct goals of epilepsy treatment to exist: to reduce seizure frequency and severity, to improve function, to enhance quality of life, to promote coping, to improve external circumstances, to prevent premature death, and (in children) to promote growth and development. However, these goals are subject to certain qualifications. For example, seizure frequency and severity is not to be reduced under all conditions, but only when such reduction can be expected to have beneficial effects on quality of life or on life expectancy (the two ultimate goals).

1. STRUCTURAL MODEL OF ADAPTIVE EXPERT SYSTEM

The expert system can be described as followed:

$$\begin{aligned}
&T \times X \times S \xrightarrow{\alpha_1} M \times T;\\
&T \times M \times S \xrightarrow{\alpha_2} C \times T;\\
&C \times T \times X \times S \xrightarrow{\alpha_3} R \times T;\\
&T \times \dot{X} = \{A \times T\} X \times T + \{A \times T\} U \times T;\\
&T \times Y = \{D \times T\} X \times T;\\
&T \times R \times Y \xrightarrow{\alpha_4} C \times T;
\end{aligned} \quad (1),$$

where T - time set of curing, X - set of system states (order of medical decision rules), S - environment options (data of EEG analysis, blood parameters), [3] M - motivation (psychological feedback), R - goals (preferred EEG parameters and patterns, absence of seizures), Y - real results (current clinical and pharmacological patient states), A, B, D - parameters matrixes, $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ - intelligence transfer rules based on medical advices. The structural model of adaptive expert system and patient is presented on fig. 1.

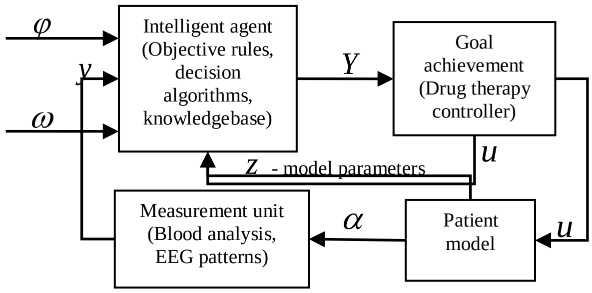

Figure 1. The structural model of adaptive expert system and patient.

According to this scheme the intelligent agent is a dynamic block and is described by formula

$$\dot{Y} = F(Y, y, u, \omega, \varphi, \alpha, t),\; y(t) = y_0, t \ge t_0 \quad (2)$$

It analyses goal signal φ (desired concentration of drugs, EEG parameters), disturbance ω (level of metabolism of a patient), controlling signal u (drugs doze, composition, injection schedule), output parameters y and defines the desired patient behavior. Let's consider that Y satisfy the equation:

$$Y = Y(t) \in Q_d(t), t \ge t_0, \quad (3)$$

where Q_d is defined finite set. The expert system approximation is

$$\begin{aligned}&\dot{X} = \Phi(X, u, \omega, \varphi, \alpha, t);\\ &X(t) = X_0, t \ge t_0\end{aligned}, \quad (4)$$

where X is vector of systems states [6]:

$$X = \begin{bmatrix} x \\ = \\ y \end{bmatrix} \quad (5).$$

The vector $\bar{y}$ is followed:

$$\bar{y} = \bar{\bar{F}}\left(\bar{y}, u, \omega, \varphi, \alpha, t\right) \qquad (6).$$

The boundaries equation is:

$$X = X(t) \in Q(t), t \geq t_0 \qquad (7).$$

The task of intelligent controller synthesis can be presented in the following way: to choice of the controller algorithm $u(X,t)$ and select function $\bar{\bar{F}}\left(\bar{y}, u, \omega, \varphi, \alpha, t\right)$ that equation (4) where $\Phi(\cdot) = \left[f^T(\cdot), \overline{F^T}(\cdot)\right]^T$ satisfy boundaries (7).

2. PATUIENTS TRANSFER FUNCTION FOR THE ARTIFICIAL INTELLEGENCE SYSTEM

A human can be formalized with linear system of differential equations [4, 5]. The patient with epileptically disorders can be approximated as three successive blocks: time delay $e^{-\tau s}$, where τ is time delay, prognosis one $\frac{(T_f s + 1)}{(T_i s + 1)}$ and block of neuromuscular activity $\frac{K}{(T_{nm} s + 1)}$. The summarized human transfer function is followed:

$$W(s) = \frac{K e^{-\tau s}(T_f s + 1)}{(T_i s + 1)(T_{nm} s + 1)}, \qquad (8)$$

where $T_f = 1$ $, 6 \leq T_i \leq 8$, $0.1 \leq T_{nm} \leq 0.3$ - coefficients of blocks, τ - pure time delay, $0.01 \leq \tau \leq 0.40 s$. The block $\frac{(T_f s + 1)}{(T_i s + 1)}$ defines human ability to change his dynamic properties according to the aims of control. The operator $\frac{1}{(T_i s + 1)}$ formalizes the drug action on the patient as the therapy effect is not immediate. The value of T_i depends on drug types, metabolism. The block $(T_f s + 1)$ shows patient abilities to anticipate of seizures spreading. The MATLAB scheme of the patient's model is presented on figure 2.

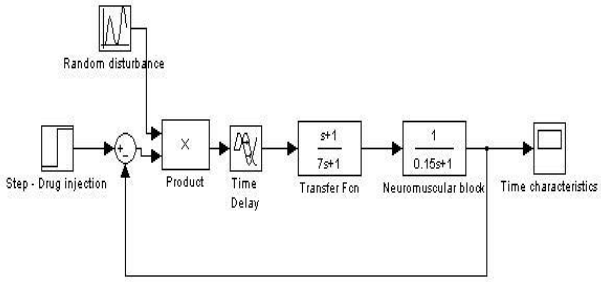

Figure 2. The patient transfer function, MATLAB scheme.

3. FURTHER INTENTIONS AND CONCLUSIONS

The expert systems' developing is a complicated task and requires large knowledge base and symptoms' set. The intelligent controller is able to optimize treatment process. The optimal control analysis methods allow creating strong mathematical model of the medical expert system. They help to investigate the dynamic properties of the intelligent agent at the step of elaboration. The suggested models could simplify the design of software systems in the domain of brain pathologies. The drawbacks consist in the fact that each patient has his own normal set of parameters and knowledge base development becomes more complicated. The further research perspective is quality parameters definition which will allow estimating work results (diagnosis) of the treatment using the adaptive expert system.

References

1. ***Karlov V. A.*** *Epilepsy. – Moscow: Medicine Publishing Company, 1990. – p. 335.*
2. ***http://www.nlm.nih.gov/medlineplus/***
3. ***Pospelov D. A.*** *Situation control: theory and practice. – Moscow: Nauka, 1986. - p. 288.*
4. ***Shibanov G.P.*** *Quantity estimation of human's action applied for technical systems. – Moscow: Mashinostroenie Press, 1983. - p. 263.*
5. ***Chi-Tsong Chen.*** *Analog and Digital control system design. – N. Y.: N. Y. State University, 1995. – p. 600*
6. ***Pupkov K. A., Konikov V. G.*** *Intelligent systems. - Moscow: MGTU Bauman University Press, 2003. – p. 348.*

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