CIRCADIAN RHYTHMS EVALUATION

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Abstract

Everyone has their own circadian rhythm, which is in various stages of life influenced by many different influences. Seniors and other people with disabilities tend to have circadian rhythms much more regular than the rest of the population. In the case of an effective way of detecting circadian rhythms, their interpretation and subsequent detection of deviations and abnormalities can deduce not only for acute medical problems but also the person watched the long slow rhythms reflected the changes reflecting the development of chronic, more or less serious diseases. The problem of circadian rhythm evaluation could be treated by many different techniques. The fuzzy logic is very promising technique.

1 Introduction

The signals that are produced by human beings can hardly be interpreted by precise mathematical methods without excessive demands on computing capacity. Description of processes using fuzzy logic techniques can effectively address these complicated processes very efficiently. For the purpose of testing the possibilities of fuzzy logic approaches to solving the problem of evaluation of circadian rhythms controlled by the person monitoring of physical activity a person living alone in the apartment was implemented rules based on expert knowledge of experts in this field. This base was implemented using Matlab fuzzy toolbox. In addition, a group of simulations was performed to confirm the functionality of decision-making base. In the final state test decision was made based on a series of real data from measurements of physical activity observed people in a training flat of remote home care VSB - TU Ostrava.

2 Fuzzy logic

The core of expert systems, knowledge bases, which are stored in a formalized expert knowledge of problem areas in which the expert system to provide support in decision making. Fuzzy expert systems are used for the formalization of knowledge known IF-THEN rules in the form

IF (premise, antecedent) THEN (consequence, consequent)

Antecedent and consequent of fuzzy rules are vague statements - their truth value lies in the interval <0, 1>.

The structure contains fuzzy statements linguistic variables, their linguistic values and fuzzy logical connectives. A typical form is an expression

(X is A)

where X is a linguistic variable and A is the appropriate language value. Vagueness of language values is yet formalized the fuzzy sets.

Linguistic variable can be described as an ordered four

$$\left\langle X, LX, U, M_X \right\rangle \tag{1}$$

where X is the name of linguistic variables, LX is a set of linguistic values, U is the universe and MX is a function expressing the importance of linguistic values using fuzzy sets.

Fuzzy implication IF (x is A1) THEN (y is B1) expresses the causal relationship between linguistic variables x and y. If the language variable x takes the value of their language A1, the result is a condition where other language variable y takes its linguistic value B1. This rule can be according to the above principles expressed as a fuzzy relation R

Consider now the case when we know that linguistic variable x takes its value as a different language A2, then (x is A2). We ask what language value now becomes linguistic variable y?

To answer this question we use a process called approximate reasoning (approximate inference). It is a process of logical reasoning, so its design will use classical reasoning rules modus ponens. This rule allows us to deduce the truth of B based on the truth of statement A.

The Matlab fuzzy toolbox is very useful tool for fuzzy logic systems. It has been used for realization of own fuzzy model for circadian rhythm evaluation.

3 Fuzzy Model for Circadian Rhythm Evaluation

For the construction of fuzzy rules based model for evaluation of circadian rhythms has been defined seven basic input linguistic variables. With these input linguistic variables are based on recognized only four basic rules of crisis situations. This chapter describes the input linguistic variables, their linguistic values and ways of calculating (or determine) the value of linguistic variable and its standardization.

There were defined following input variables, Intensity of Movement, Time of Inactivity, Position Changes, Stay in one position, Character of Position, Time of Activity, Chronology of Movement. For each variable were defined its language values and function of possibility. After that the normalization procedure was finished.

Normalized input value of the variables is dependent on day and night. For day and night time is the maximum observed value of input variables. These can then standardizing hilarious detected current values of the variables. The example of normalization procedure is displayed for variable Intensity of Movement (INP).

$$INP_{norm}(t) = \begin{cases} \dfrac{INP(t)}{INP_{\max,day}} & pro\ t \in \left\langle t_{day}, t_{night} \right\rangle \\ \dfrac{INP(t)}{INP_{\max,night}} & pro\ t \in \left\langle t_{night}, t_{day} \right\rangle \end{cases} \tag{2}$$

Each fuzzy input variable has to have own function of possibility. The functions were realized in FIS editor of Matlab. The shape of function of possibility was triamp mostly.

For the chosen output language variable was defined based rules. Each contains more ascendant rules for recognizing a particular consequents. For each consequent is defined by multiple rules. Fuzzy model was created as a fuzzy model type mamdami realized in FIS editor.

Table 1: FUZZY MODEL PARAMETERS FROM FIS EDITOR

[System]
Name='Cerny_3'
Type='mamdani'
Version=2.0
NumInputs=7
NumOutputs=1
NumRules=12
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='lom'

The following tests of fuzzy model properties was designed own software, which uses functions of fuzzy toolbox. The basic function [out, IRR, ORR, ARR] = evalfis(vstupni,fismat). The GUI were designed too. This gui allows user to set up values of input variables to simulate the fuzzy model evaluation in time. It is very useful for prediction testing. The prediction test are not a part of FIS editor, which allows only test on single values of input variables.

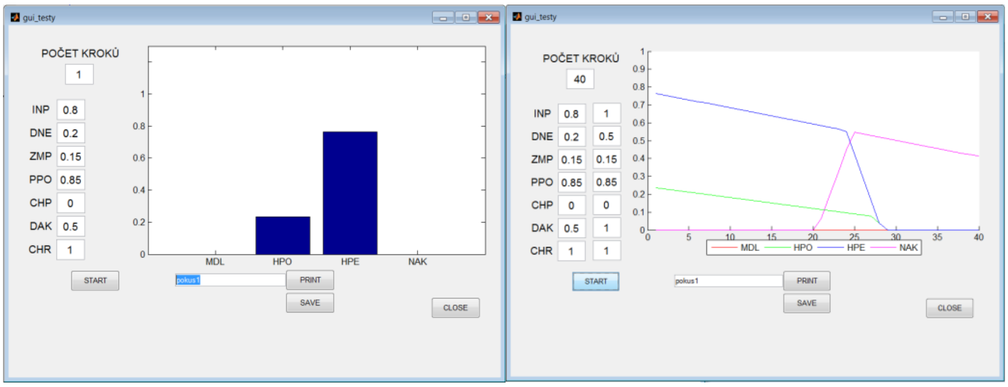

Figure 1: GUI for fuzzy model tests

4 Results

The first tests were carried basis independence rules fuzzy model. These tests are conducted using MATLAB tools FIS editor, which was created by a fuzzy model to evaluate deviations circadian rhythms. Adjusting the values of input variables in a graphical environment FIS Editor Rule viewer was verified by the independence of basis rules. Based on the dependencies, the initial fuzzy model has been changed to modified version listed in Table 1. There was also a function of addiction treatment input variables into a form that is presented in this work. By using the fuzzy model, rules and functions dependent input and output variables in fuzzy model do not to monitor status flag of person. The decision level for detection alarms were considered value functions depending output variables greater than or equal to 0.6. This value is considered in fuzzy models for a standard minimum value for the recognition of the value function based output linguistic variables.

Basis rules tests were then carried out also in the generated program to test the fuzzy model. There were verified by the output variable with maximum values of input variables for each of the decision-making rules.

For testing purposes, the decision-making bases recognized only four states monitored person. They are monitored by acute symptoms of diseases which are caused by a reduction, respectively increasing physical activity. States are recognized fainting - a condition where the monitored person falls into a complete physical inactivity. Furthermore, hyperactivity followed by hypoactivity during the time of day - during wakefulness. Unusual nocturnal activities are a further output fuzzy decision system.

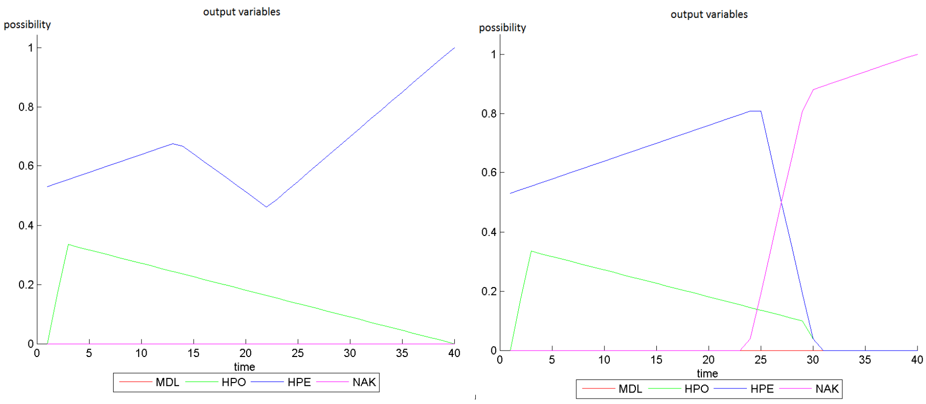

Figure 2: Simulation results of hyperactivity and hypoactivity evaluation in Circadian Rhythm

To confirm the functionality of a fuzzy model for the evaluation of deviations cirkadiálního rhythm was designed algorithm tested on a sample set of real data.

Data was measured in a training flat for remote home care systems. During the measurements were simulated critical conditions. In the course of the day was observed hyperactivity simulated person, normal and reduced physical activity of people in the daylight hours and night trips to the bathroom. These crises are fundamental crisis states observed in the remote home care.

When selecting boundaries for the decision on the state of crisis detected a fuzzy model to the level of 0.6 would be detected five crisis situations. Three of them correspond to the simulated states - two unusual nocturnal activity and hyperactivity in the morning. Detection of fainting in the night hours is wrong. Its removal is possible by changes of basis of rules in fuzzy model.

5 Conclusion

There was defined as an integrated fuzzy model that can evaluate the circadian rhythm and its variations. It was defined by its own set of input linguistic variables, membership functions and the method of their preparation for the fuzzy model. Based on expert knowledge and experience was defined based decision rules fuzzy model and a core group of states evaluated and deviations cirkadiálního rhythm. This way, the model was subjected to independent testing, development testing rules and values of output variables to input variables change. Tests have shown the usability of fuzzy model for the analysis of rhythm cirkadiálního both simulated data and on measured data in a controlled experiment testing the system for monitoring the position of the person in the apartment. Tests also show the predictive ability of fuzzy model, which is a significant benefit in the evaluation of circadian rhythms. Prediction of state of emergency and acute problems can be avoided.

Designed and implemented a fuzzy model is fully functional, but cannot be considered a final solution to complex issues such as evaluation circadian rhythm.

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