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WEATHER PREDICTION USING FUZZY PETRI NETS

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Abstract— In fields such as economy, agriculture, weather etc., forecasting plays an important role as it predicts a way to vague situations and events. Weather prediction plays a crucial role as it provides about Weather condition which is a main aspect in the field of agriculture. In this work, Fuzzy knowledge rule base technique is used to predict the objects contained in atmospheric temperature and wind speed. Fuzzy Petri nets are used for classification of data with linguistic variables.

Keywords— **Temperature, Wind speed, Defuzzification**

I. INTRODUCTION

Background of this study is an attempt to predict the range of temperature where temperature and wind speed are considered and ranges from very low to very high. Wind speed is a main aspect which affects the degree of temperature as it distributes energy. Predicting weather condition cannot be exact but it can be an alarming fact so several uncertainty aspects are used in weather forecasting. All decisions made in Meteorology field are based on uncertainty. As fuzzy logic inference has a lower percentage of error many researchers opt for fuzzy logic applications in many fields.

Temperature

Temperature is a physical quantity that expresses hot and cold.

Wind speed

Wind speed or wind velocity is a fundamental atmospheric rate. Wind speed affects weather forecasting, aircraft and maritime operations, construction project, growth and metabolism rate of many plant species and countless other implications.

Relationship between temperature and wind speed

Changes in temperature causes air to move from high to low pressure which is a wind flow. Difference in air pressure and wind is called temperature gradient which takes place between places. Greater temperature difference results in increase in wind speed. Wind speed redistributes energy around.

Petri net and Fuzzy petri net

A Petri net designs the model of a system which happens simultaneously. A petri net consists of a collection of positions and transformations, where tokens are carried within positions over arc. Arcs connect positions and transformations.

Events and conditions are important concepts in a petri net. Events are movements which takes place in a system. Activities rely on the state of the system. States are the conditions which describes if the state is either on or off.

Positions are something which happens under some restrictions and transformations are activities which happens between positions. Positions and transformations are interlinked by arcs which are directed. Between a position and transformation there exists an arc. Position holds tokens which moves among the positions within the system.

Transformation rule:

In order to transformation occur all the input positions should have at least one token in it. As transformation is performed one token is removed from all input positions and one token is added to all its output position.

Definition: 2.1

A petri net is a tuple $PN = (P, T, I, O)$

$P = \ collection\ of\ positions\ \{P_1, P_2, P_3, \dots \dots P_m\}, m \geq 0$

$T = collection\ of\ transformations\ \{T_1, T_2, \dots \dots . T_n\}, n \geq 0$

$I = \ input\ activity$

$I: T \to P^m$*is the input activity, a mapping from transformation to positions*

$O = \ outputactivity, a\ mapping\ from\ transformation\ to\ positions$

Definition: 2.2

A fuzzy petri net is a tuple $N = \{P, T, S, I, O, \alpha, \beta, \gamma, M_0\}$ where

$P, T, S\ finite\ collection\ of\ postions, transformations, statements$

$I, O\ is\ the\ input\ and\ output\ activity$

$\alpha: P \to S\ is\ the\ statement\ binding\ functions$

$\beta: T \to [0,1]\ is\ the\ degree\ of\ truth\ function$

$\gamma: T \to [0,1]\ is\ the\ entry\ function$

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$M_0 : P \rightarrow [0,1]$ *is the primary label*

Definition: 2.3
Composition of two sets

Max-Min composition $P(X,Y) \circ Q(Y,Z)$ operation is defined by

$$\mu_{P \circ Q}(x,z) = \max_{y \in Y} \min[\mu_P(x,y), \mu_Q(y,z)] \ , \forall x \in X \ \& \ z \in Z \qquad \textbf{(1)}$$

Model

If M is a marking of N enabling transformation t and $M^{'}$ the marking derived from M by the firing transformation t, then for each $p \in P$ [3]

$$M^{'}(p) = \max(\min(M(p_{i1}), M(p_{i2}), ...M(p_{ik})) * \beta(t), M(p))$$

if $p \in O(t)$, $M(p)$ *otherwise* **(2)**

firing is done using equation (2)

II. EXPRESSING DEGREE OF TRUTH FOR TEMPERATURE AND WIND SPEED

Here the consideration for temperature scales From $5^{\circ}C - 25^{\circ}C$

$$\begin{array}{c|ccccc} temp & 5 & 10 & 15 & 20 & 25 \\ \hline VL & 1 & 1 & .8 & .4 & 0 \\ L & .8 & 1 & .6 & .4 & 0 \\ N & 0 & .7 & 1 & .6 & .2 \\ H & 0 & .2 & .4 & 1 & .8 \\ VH & 0 & 0 & .2 & .4 & 1 \end{array}$$

Here the consideration for wind speed scales from 2-10 km/hr

$$\begin{array}{c|ccccc} ws & 02 & 04 & 6 & 8 & 10 \\ \hline VL & 1 & .4 & .2 & 0 & 0 \\ L & .6 & 1 & .5 & .2 & 0 \\ N & 0 & .6 & 1 & .4 & .2 \\ H & 0 & .2 & .5 & 1 & .3 \\ VH & 0 & 0 & .3 & .4 & 1 \end{array}$$

Very Low-VL; Low-L; Normal-N; High- H; Very High-VH

III. DEVELOPMENT OF FUZZY PERTI NETS

Here we have the collection of positions $P = \{P_1, P_2, P_3, P_4, P_5, P_6\}$, the collection of transformations $T = \{t_1, t_2, t_3\}$, the input activity I and the output activity O in the form : $I(t_1) = \{P_1, P_2, P_3\}$, $I(t_2) = \{P_1, P_2, P_3\}$, $I(t_3) = \{P_1, P_2, P_3\}$, $O(t_1) = \{P_4\}$, $O(t_2) = \{P_5\}$, $O(t_3) = \{P_6\}$, the degree of truth function β: $\beta(t_1) = 1$, $\beta(t_2) = 0.4$, $\beta(t_3) = 0.2$, the entry function γ: $\gamma(t_1) = 0.4$, $\gamma(t_2) = 0.3$, $\gamma(t_3) = 0.2$, the primary label $M_0 = (1, 1, 0.8, 0.4, 0)$

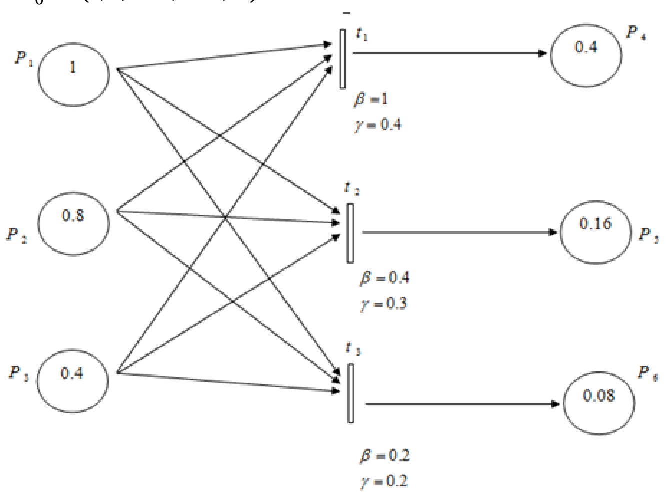

Figure 1: the markings after firing where all transformations are enabled

Interactional matrix between μ_{tempVL} and $\mu_{windspeedVL}$:

$$\mu_{VL\_VL} = \begin{array}{c|ccccc} temp \backslash ws & 1 & 0.4 & 0.2 & 0 & 0 \\ \hline 1 & .4 & .16 & .08 & 0 & 0 \\ 1 & .4 & .16 & .08 & 0 & 0 \\ 0.8 & .4 & .16 & .08 & 0 & 0 \\ 0.4 & .4 & .16 & .08 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{array}$$

$$\mu_{VL\_VL} = \begin{array}{c|ccccc} temp \backslash ws & 1 & 0.4 & 0.2 & 0 & 0 \\ \hline 1 & .4 & .16 & .08 & 0 & 0 \\ 1 & .4 & .16 & .08 & 0 & 0 \\ 0.8 & .4 & .16 & .08 & 0 & 0 \\ 0.4 & .4 & .16 & .08 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{array}$$

Firing is done for all linguistic variables and interactional matrix is found for respective linguistic variables.

DEFUZZIFICATION OF TEMPERATURE AND WIND SPEED

Degree of truth is obtained using Max min composition (1)

$$TEMP = \frac{\forall_i \sum x_i \mu(x_i)}{\forall_i \sum \mu(x_i)}$$

$$x_i = [5 \quad 10 \quad 15 \quad 20 \quad 25]$$

LINGUISTIC VARIABLE	DEGREE OF TRUTH $\mu(x_i)$	TEMPERATURE $(\boldsymbol{V_k})$
Very Low	$[0.02 \quad 0.02 \quad 0.016 \quad 0.008 \quad 0]$	10.9375
Low	$[0.016 \quad 0.02 \quad 0.012 \quad 0.008 \quad 0]$	11.0714
Normal	$[0 \quad 0.014 \quad 0.02 \quad 0.012 \quad 0.004]$	15.6
High	$[0 \quad 0.004 \quad 0.008 \quad 0.02 \quad 0.016]$	20
Very High	$[0 \quad 0 \quad 0.004 \quad 0.008 \quad 0.02]$	22.5

Table 1: shows defuzzified values of Temperature

$$WS = \frac{\forall_i \sum x_i \mu(x_i)}{\forall_i \sum \mu(x_i)}$$

$$x_i = [2 \quad 4 \quad 6 \quad 8 \quad 10]$$

LINGUISTIC VARIABLE	DEGREE OF TRUTH $\mu(x_i)$	WIND SPEED $(\boldsymbol{V_k})$
Very Low	$[0.04 \quad 0.016 \quad 0.008 \quad 0 \quad 0]$	3
Low	$[0.024 \quad 0.04 \quad 0.02 \quad 0.008 \quad 0]$	4.2608
Normal	$[0 \quad 0.024 \quad 0.04 \quad 0.016 \quad 0.008]$	6.1818
High	$[0 \quad 0.008 \quad 0.02 \quad 0.04 \quad 0.012]$	7.4
Very High	$[0 \quad 0 \quad 0.012 \quad 0.016 \quad 0.04]$	8.8235

Table 2: shows defuzzified values of Wind speed

CALCULATING QUANTIFIABLE VALUE OF TEMPERATURE

There are several methods for calculating a quantifiable value for fuzzy set but the one to be used in this project is Centroid method.[6]

$$TEMPERATURE = \frac{\sum_{k=1}^{n} \mu(V_k) \times V_k}{\sum_{k=1}^{n} \mu(V_k)}$$

$\mu(V_k)$ is the truth degree value of each variable (Temperature and Wind speed)

V_k is the value of the variable defuzzified

WS / TEMP	VL	L	N	H	VH
VL	6.96875	6.4863	6.9744	7.7930	9.0157
L	8.3809	7.6661	7.5788	8.1343	9.1982
N	13.5	12.36	10.891	10.5538	11.082
H	18.111	16.852	14.685	13.7	13.79
VH	20.727	19.46	17.061	15.789	15.662

Table 3: above shows the relationship connecting temperature and wind speed

IV. CONCLUSION

An attempt to forecast weather has been done in this dissertation. Fuzzified temperature and wind speed values are defuzzified using centroid method in table 3 and the apparent temperature value is calculated. The final table shows that lower the temperature faster the temperature increases according to increase in wind speed

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