The Use of Petri Networks with Fuzzy Interval for the Diagnosis of Hybrid Systems

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***Abstract*—Numerous methods have been put out in relation to Petri nets, however although sharing the same name, they are based on distinct ideas and are only loosely consistent with the Petri net theory.We have to arrive at a very accurate interval because tolerance is crucial in the mechanical area. This aphorism has given us the idea to create a tool that considers time interval in addition to modeling. In this study, we describe a strategy based on the fuzzy system, petri nets, and several theories of characteristics. The system that has to be controlled is modeled using a Petri net. The** performance **of diagnostic approaches depends on the model used. Obtaining and using a model to build a diagnostic system is a complex and difficult task, especially for uncertain systems, because they are characterized by uncontrollable events .**

In this paper, we describe an approach that is based on various feature theories combined with fuzzy system and Petri dish. This tool is designed to improve the modeling and quality of components delivered as an application.Before the space variants, the part definition must be saved with this command.Keywords— Modelling, Fault Diagnosis, Petri networks, fuzzy logic, diagnostic, artificial intelligence

I. Introduction

As a result, expert systems, fuzzy set theory, FPN, artificial neural networks, and genetic algorithms have been extensively employed to tackle certain diagnostic challenges. These techniques are based on artificial intelligence.

The (PNFI) is extended from an object-oriented Petri net, it combines between Petri Nets Interval (PNI) associates with each transition interval [A, b], the shot is instantaneous and the networks of petri fuzzy Petri's networks are known for their ability to represent the characteristics and interactions between the different components of a manufacturing workshop. They allow to describe the precedence constraints (sequences), the choices, the synchronization mechanisms and the parallelism. In terms of modeling, Petri's network tools are used in the literature to describe and solve several problems deemed "difficult". In particular, time-constrained processes in which either the minimum time of an operation or the interval to which their durations must belong must be specified. The quality and even the conformity of the product depend directly on compliance with these constraints.

The general framework of our research is the analysis of a dynamic system where the time information is known imperfectly. This has two goals formalize and program Petri Temporal networks with treatment of some theoretical problems and investigate the use for surveillance

Studies on the design or planning workshops limited in timeMostly on the optimization of the production rate.

The processes of these workshops Subject to time constraints. [1], [2] Most of these studiesAre based on Petri Nets models, which are the study of robustness properties, where the products length of stay must be guaranteed even in case of disruptions.P-time Petri nets are completed by this application.It is possible to define any parameter without parameters to be modeled in the production process.

II. Petri nets fundamentals

PN is used to study a variety of properties, including parallelism, asynchronousness, distributedness, parallelism, non-deterministicness, and stochasticness. Industrial processes, such as power systems, generating plants, and computing systems, can be modeled using PN. PN consists of nodes and arcs. Nodes are made up of states/events that allow the transition from one state to another (bag theory) in p(a). Arches are made up of

(1) P = {p1, p2…., pm} is a non-empty set of place nodes
(2)T = {t1, t2, ….tm} is a set of transition nodes
(3) I : (P XT) → N is the input function to represent the transition node-to-bag node mapping, where N is a set of non-zero integers
(4) O : (PXT)→ N is the output function to represent the bag node-to-transition node mapping, where O is a set of negative integers
(5) F ⊒ (PXT) ∪ (TXP) is a set of directed arcs
(6) M : P → N is the initial marking for the mapping from the non-zero integers N. M(p) is the number of tokens assigned to place node p under M. Marking is a primitive expression for PN (such as places and transitions).
indicates how many tokens are on node p under M.
Marking
Marking is a way of assigning tokens to the locations of a programmable node (PN).

Tokens are a primitive way of thinking about PN (e.g., places, transitions, etc.).

Tokens are assigned to and reside in the places of the PN.

The number and location of the tokens may change when a PN is executed.

Tokens are used to specify the execution of the PN.[6]

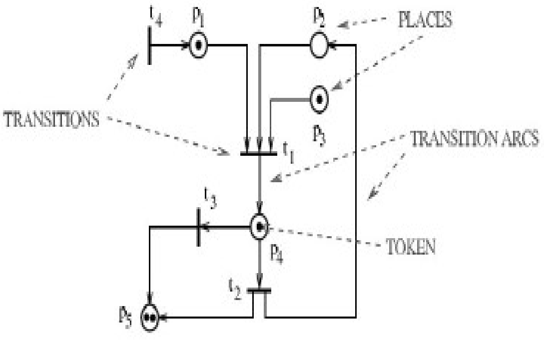


Fig. 1. shows of all elements of PN.

III. FORMALIZATION OF OUR PETRI NETWORK

In order to capture more information the diagnosis by petri nets, many authors have developed (PNFI).

For us, we will make the Petri lattice structure at fuzzy intervals. It is defined as quadruplet <N, F (t), IS, M0>

Where: N = <P, T, Pre, Post> is a Petri net such that

P = {p1, p2, ..., pn} is a finite set of places

T = {t1, t2, ..., tm} is a finite set of transitions

Pre: a multi set on P x T (back impact function)

Post: a multi set on T x P (front impact function).

F (t): T [0,1] associative function which establishes a time-varying credibility value F (t) for each transition ti of T. µ represents the degree of truth of the proposition corresponding to the transition. The instant t corresponds to the time instant t when the external event Ei will be received by the modeled system.

IS: $P \rightarrow Q \cup \{-\infty, +\infty\} \times Q \cup \{-\infty, +\infty\}$ defines the intervals associated with the places on the network.

$Pi \rightarrow ISi = [ai, bi]$ with $0 \leq ai \leq bi$

M0: is the initial marking

Principle of fuzzy logic

For example

If µA is the membership function of the fuzzy set A

$$\forall x \in U \quad \mu_A(x) \in [0;1]$$

if $\mu = 0.30$

X belongs to the fuzzy set A with a degree of belonging of 30%

Degree of belonging = value of truth.

A fuzzy set is totally determined by its membership function

In below a diagram showing the differences between the classical logic fuzzy logic Logic

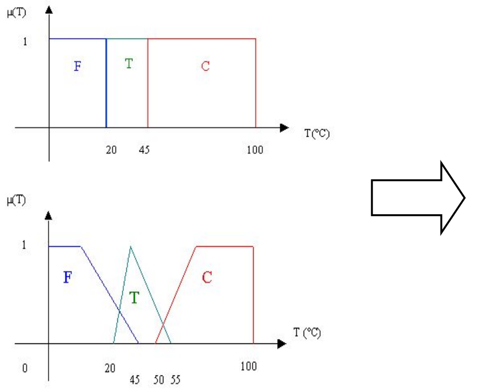


Fig. 2. differences between the classical logic fuzzy logic

A. Integration of fuzzy logic into the petri net

The applications of fuzzy logic are extremely numerous and varied. Most Current are fuzzy control, fuzzy expert systems, reasoning from case and fuzzy recognition of forms. In the context of surveillance and diagnosis ,we find mainly expert systems, case-based reasoning and recognition of forms.

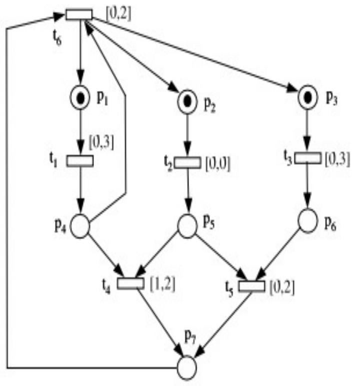


Fig. 3. Example of a Petri net at the interval

Fuzzy logic makes it possible to formalize the representation and processing ofImprecise or approximate knowledge. It offers the possibility of dealing with systems of high complexity in which, for example, there are factors human resources. It intervenes in the manipulation of imperfect knowledge.

Its use in areas such as decision support or diagnosis seems therefore natural in as it provides a powerful tool for automatically human, naturally imprecise. Fuzzy logic is thus considered [5] as the only framework within which and uncertainties, which also permits the treatment of certain incomplétudes, and the only framework in which one can deal with digital and of the knowledge expressed symbolically by natural language skills.

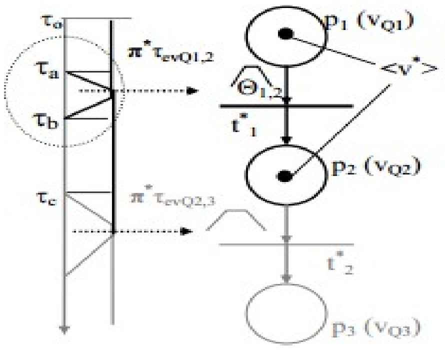


Fig. 4. Integration of fuzzy interval

In these different contexts (help with diagnosis,Decision), the human expert expresses knowledge or data in a language natural inaccuracy; The fuzzy logic thus makes it possible on the one hand to take the inaccuracies inherent in the data and, on the other hand, to the expression of the rules which make it possible to formulate a diagnosis or action. For example, in [5], the architecture of a antenna detection / diagnosis, in which the fuzzy logic intervenes in the form of a fuzzy expert system and in the classification steps [1]:

- It is necessary to determine the Fuzzy state intervals especially when there are loops in the system, and the case of infinite sequences.
- If two transitions can be crossed with firing dates (fuzzy) a and b, it is necessary to calculate the possibility Π (a = b) (and necessity N (a = b)) so that they can be crossed at the same time
- study the spread of fuzzy sets sub-standard as well as fuzzy sets with non-standard shapes

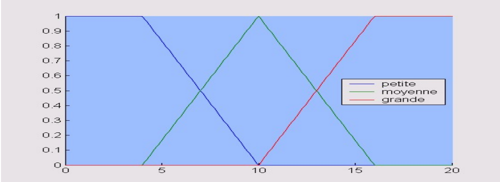
IV. FUZZY LOGIC AND ADVANCED CONTROL IN INDUSTRIAL

Fuzzy logic proposes a much more pragmatic than mathematical approach to problems, in some problems where mathematics are struggling through impossibility or modeling difficulty, fuzzy logic brings an astonishing efficiency. Fuzzy logic is very similar to the process of human thought. It implements a set of rules as, implicitly, we use them every day.

She appreciates the variables approximate inputs (low, high, far, close) made same for output variables (light or heavy braking), and establishes a set of rules to determine the outputs based on the entries [2].

A. Fuzzification :

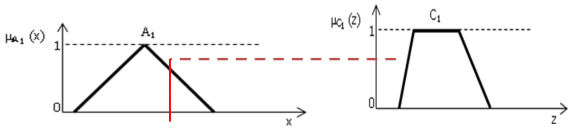
The fuzzification is the first step in the realization of a fuzzy control. It transforms every real value input (extent) a fuzzy set. By assigning its appearance according to each class previously defined.



Fuzzy inference:

This block expresses the relationship that exists between the input variables (expressed as linguistic variables) and the output variable (also expressed as a linguistic variable).

Aggregation: Knowing that for a given state of the inputs, several rules can be validated to give instructions to the outputs, it is necessary to have a method of composition to obtain the final result.



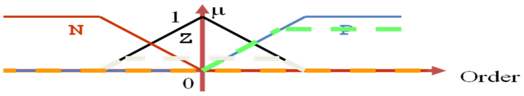
X0

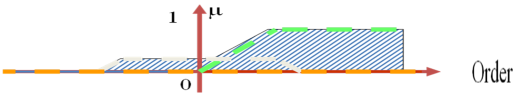
Defuzzification:

The fuzzy subset Y of V universe of discourse has been calculated by the inference mechanism, the defuzzification interface aims to turn it into a non-fuzzy value enabling the effective control of the system. This operation is performed by the operator defuzzification [3]

Step 1: Truncation of fuzzy sets to their highest level of membership.

Step 2: Operation "or" fuzzy sets applied to output (max).





Step 3: Determining the order.

Center of gravity

Average of maximums

In addition, in order for the rules to be applied in fuzzy space and be described in terms of fuzzy variables, they must already be fuzzy in the context of fuzzy theories. In this study, we use two approaches: first, we define the bounds of intervals using mathematical equations, and second, we apply the rules to identify defects. The qualitative mathematics that permits mathematical operations on qualitative numbers must be defined in order to accomplish this. Subtraction as well as addition are the fundamental processes needed [4].

V. THEORETICAL PROBLEMS IN PETRI NETWORKS WITH FUZZY INTERVAL

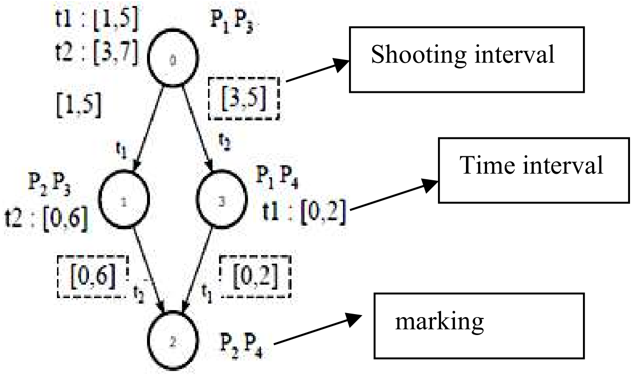
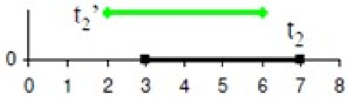


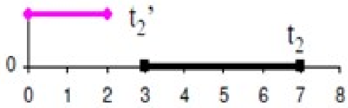
Fig. 5. Interval Petri Network Application

Our contribution is the integration of the fuzzy logic in the time period given, [7] we propose the method of fuzzification, defuzzification and interference.



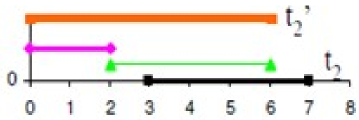
Shooting from t 1 to 1 (date min)

T'2 = t2-1= [3-1 ,7-1] = [2 , 6]



Shooting from t 1 to 5 (date max)

T'2 = t2-5= [3-5 ,7-5] = [0, 2]

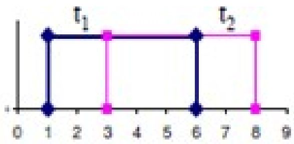


Taking into account all shooting moments

T'2 =t2-t1= [3,7] - [1,5] = [0,6]

Shooting from t3

New time interval of t1 and t3

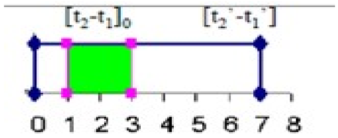


t'1 = t1-t3 = [5,6] - [0,4] = [1,6]

t'2=t2 – t3 = [7,8] - [0,4] = [3,8]

[t2-t1]0 = [7,8] - [5,6] = [1,3] > 0

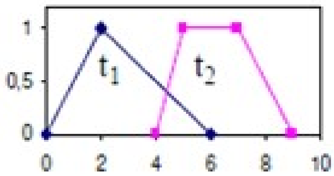
⇨ Only t1 is tirable



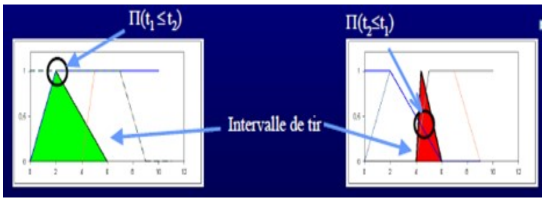
Distribution of possibility πti (x) associated with each transition

Notion of 'possibly' / 'necessarily' before or after πti (x)

Quantitative verification with degree of type possibility at place of response yes / no



Ti before tj: calculation of measures of possibility π



So now we apply the blur to the interval we end up with the following graph[8]

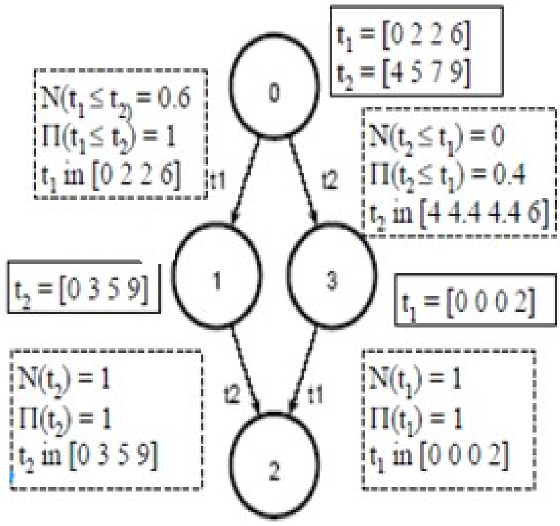


Fig. 6. Application of fuzzy interval Petri Network

VI. LINEARIZATION APPROXIMATION

Tolerances on each parameter must be calculated before the model is constructed. A simulator based on actual numbers from manufacturing data might be used for this particular reason. The steps of this computation procedure and the underlying assumptions are explained in the subsection that follows. [8]

We assume that there is very little variance in the parameters around the mean. Next, using first order linear growth in the vicinity of the standard setting [2], we can approximate the relationship (eq. 3):$\Delta C \in [\Delta Cmin, \Delta Cmax]$

The values objectives of parameters C, C1, h1, h2, and Ve are, in that order, C0, C10, h10, C20, V20, and Ve0.

We are able to compose the following once equation (3) has been linearized about the operational point:

$$C \approx C_0 + \frac{\delta C}{\delta c_1}(c_1 - c_{10}) + \frac{\delta C}{\delta h_1}(h_1 - h_{10}) + \frac{\delta C}{\delta c_2}(c_2 - c_{20}) +$$

$$\frac{\delta C}{\delta h_2}(h_2 - h_{20}) + \frac{\delta C}{\delta Ve}(Ve - Ve_0)$$

$$\frac{1}{2}\frac{\delta^2 C}{\delta c^2}(c_1 - c_0)^2 + \frac{1}{2}\frac{\delta^2 C}{\delta h_1^{\,2}}(h_1 - h_0)^2$$

$+$ $+$

$$\frac{1}{2}\frac{\delta^2 C}{\delta c_2^{\,2}}(c_2 - c_{20})^2 + \frac{1}{2}\frac{\delta^2 C}{\delta h_2^{\,2}}(h_2 - h_{20})^2$$

(5)

This relation can be written down as:

$C \approx C_0 + \sum_{i=1}^{5}[b_i X_i + b_{ii} X_i^2]$with: (6)

$X_1 = \frac{(c_1 - c_0)}{\sigma_1}$; $X_2 = \frac{(h_1 - h_0)}{\sigma_2}$; $X_3 = \frac{(c_2 - c_{20})}{\sigma_3}$
$X_4 = \frac{(h_2 - h_{20})}{\sigma_4}$; $X_5 = \frac{(V_e - V_{e0})}{\sigma_5}$;

and $b_i = c_i \sigma_i$; $b_{ii} = c_{ii} \sigma_i^2$

where: $b_1 = \frac{\delta C}{\delta c_1}$: $b_2 = \frac{\delta C}{\delta h_1}$; $b_3 = \frac{\delta C}{\delta c_2}$; $b_4 = \frac{\delta C}{\delta h_2}$;
$b_5 = \frac{\delta V_e}{\delta V_e}$; $b_{11} = \frac{\delta^2 C}{\delta c_1^{\,2}}$; $b_{22} = \frac{\delta^2 C}{\delta h_1^{\,2}}$; $b_{33} = \frac{\delta^2 C}{\delta c_2^{\,2}}$
$b_{44} = \frac{\delta^2 C}{\delta h_2^{\,2}}$and $b_{55} = \frac{\delta^2 C}{\delta V_e^{\,2}}$

where σ_i is the standard deviation of the considered parameter.

If we assume that the variations of the parameters follow the normal distribution [9] the first approximation can be writing [11, 30]:

$$\sigma_C^2 = \sum_{i=1}^{5} b_i^2 = \sum_{i=1}^{5}\left(\frac{\delta C}{\delta x_i}\right)\sigma_i^2 \tag{7}$$

The application of the relation (7) gives us:

$$\sigma_C^2 = \frac{S^2 h_1^{\,2}}{Ve^2}\sigma_{c1}^2 + \frac{S^2 C_1^{\,2}}{Ve^2}\sigma_{h1}^2 + \frac{S^2 h_2^{\,2}}{Ve^2}\sigma_{c2}^2 + \frac{S^2 c_2^{\,2}}{Ve^2}\sigma_{h2}^2 + \frac{S^2}{Ve^4}(C_1 h_1 + C_2 h_2)\sigma_{Ve}^2 \tag{8}$$

And after simplification of this relation (8) we obtain:

$$\sigma_{Ve} = \sqrt{\frac{Ve^4}{S^2(C_1 h_1 + C_2 h_2)}\sigma_C^2 - \frac{h_1^{\,2} Ve^2}{(C_1 h_1 + C_2 h_2)}\sigma_{c1}^2 - \frac{C_1^{\,2} Ve^2}{(C_1 h_1 + C_2 h_2)}\sigma_{h1}^2 - \frac{h_1^{\,2} Ve^2}{(C_1 h_1 + C_2 h_2)}\sigma_{c2}^2 - \frac{C_2^{\,2} Ve^2}{(C_1 h_1 + C_2 h_2)}\sigma_{h2}^2}$$

VII. MODEL CONSTRUCTION

The value of the concentration, which we wish to maintain constant, affects the product's quality.

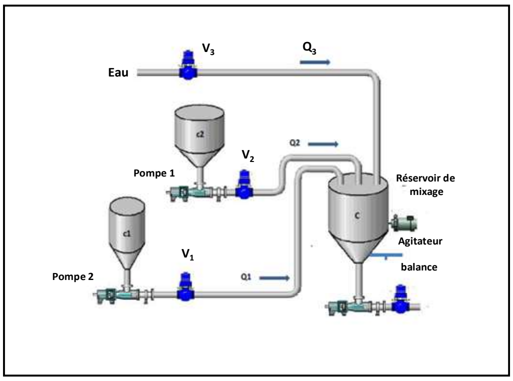


Fig. 7. Mixing System

The pressures that were looked at have a significant impact on the mixture's concentration. The theory that is developed needs to be able to clarify the variations in this concentration's value as time passes. We think that variations in the relative concentrations of the two products to be mixed and variations in the volume of water added to the combination are the causes of this variance[12] [13].

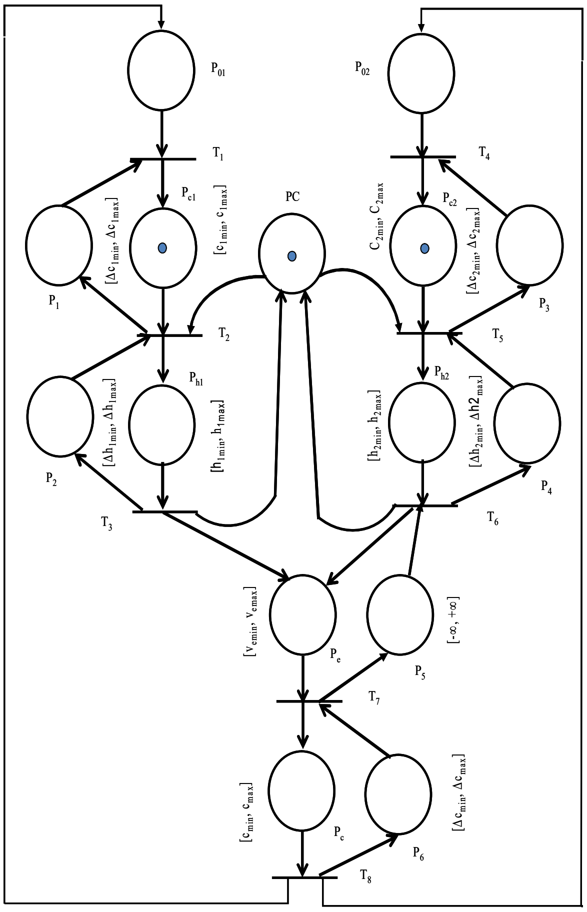


Fig. 8. Blurry Interval RoP Model of the Mixing System (7)

VIII. CONCLUSION

This article develops a new tool that will be further developed and applied soon in complex systems. It deals with the diagnosis of faults and the analysis of causes. The face of the uncertain, incomplete and unknown situation information [14].

The feasibility and the efficiency of the proposed fuzzy lattice are proved by a practical fault Example of diagnosis the results show that the new model Potential for real-time use and serves to help the Systems in case of emergency and for the automation of the system.

Further research will focus on the following directions. First, a user-friendly graphical help should be developed to Closer to FTPN for fault diagnosis to be implemented online [15].

Secondly, some extensions of the results of this document must be provided including the application third, the methodological approach used to translate from the conventional model (i.e., failure trees) to the FTPN model should also be the subject of our next research.

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