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MODELLING THE LONGITUDINAL MOTION OF AN AIRCRAFT

NOTE: *This paper was presented at the International Symposium "Research and Education in an Innovation Era", Engineering Sciences, November 20-21, 2008, "Aurel Vlaicu" University of Arad, Romania*

ABSTRACT:

The paper is making a short introduction into the field of the aircraft modeling. A basic aircraft model is build, aiming to obtain a simulation platform for different related control algorithms and for further studies on the switching controllers effects in avionics. A Matlab-Simulink implementation is provided.

KEYWORDS:

switching controllers, mathematical model, state space.

INTRODUCTION

The Stability and the Control of the airplanes was a key issue from the very beginning of the aviation. A great step forward in the field was the introduction of the automatic pilot (robot pilot, autopilot). The initial purpose of an autopilot was to replace the human pilot during cruise modes. They are expected to perform more rapidly and with greater precision than the human pilot and to make the aircraft fly in the same manner as a highly trained pilot: smoothly and with no sudden and erratic maneuvers. The modern autopilots are implemented by complex digital computers and they are able to stabilize the aircraft, protect the aircraft from undesirable maneuvers, and realize automatic landings.

Although at the first glance the reliability of the digital computers seem to be indubitable, in particular circumstances, the perturbations produced when switching between automate pilot and manual pilot may cause sudden and erratic instabilities that can cause fatal airplane crashes. Official and reliable reports on such accidents are not easy to find, but it is unanimously accepted that the on-line switching of two different controllers may produce uncontrollable transient regimes and even destabilizations.

In some previous papers we investigated the *Switching Controllers Instability* (SCI) for the case of some second order plants. The objective of this paper is to choose an appropriate mathematical model of an aircraft, that could stand for a simulation support, in further studies on control algorithms and on the switching controllers effects in avionics.

MATHEMATICAL MODELS FOR AIRCRAFTS

The first mathematical model of an aircraft was proposed by G.H. Bryan, in a fundamental early book: *Stability in Aviation*, 1911. Bryan's model is a system of 6-degrees-of-freedom equations that are still in use for the computer simulation of the most advanced of today's aircrafts, with some supplementary developments needed for the airplane control [1]. An interesting fact about the Brian's model is that his simplifying assumptions, which are affecting the model's accuracy for the subsonic aircrafts, are more suitable for the supersonic aircraft models.

$$W\frac{du}{gdt} = W\epsilon\cos\theta_0 + \delta H - uX_u - vX_v - rX_r$$

$$W\left(\frac{dv}{gdt} + \frac{rU}{g}\right) = -W\epsilon\sin\theta_0 - uY_u - vY_v - rY_r$$

$$C\frac{dr}{gdt} = -h\delta H - uN_u - vN_v - rN_r$$

$$W\left(\frac{dw}{gdt} - \frac{qU}{g}\right) = -W\phi\cos\theta_0 - wZ_w - pZ_p - qZ_q$$

$$A\frac{dp}{gdt} - F\frac{dq}{gdt} = -wL_w - pL_p - qL_q$$

$$B\frac{dq}{gdt} - F\frac{dp}{gdt} = -wM_w - pM_p - qM_q$$

Figure 1. The Brian's aircraft parametrical model

Starting from this model, that offers a structural view of the aircraft's dynamics, off-line or on-line accurate experimental models can be obtained.

An on-line identification was communicated in Ref. [2]. The identified aircraft is an L-410 Turbolet, manufactured by the Czech aircraft manufacturer LET. L-410 is a twin engine short-range transport aircraft (see **Fig. 2**).

The state vector that was used for the aircraft longitudinal motion modeling contains four state variables: aircraft velocity v, angle of attack α, pitch angle φ and derivative pitch angle φ'. The control vector contains only one input variable: the elevator angle δ.

Figure 2. The L-410 Turbolet

It was used a linear model:

$$X' = \Phi(X) + \Gamma(U) \tag{1}$$

where Φ is the plant matrix (n x n), Γ the control matrix (n x r), X the state vector (n x 1) and U the control vector (r x 1).

The state vector and the control vector are the following:

$$\mathbf{X} = [\ v\ \ \alpha\ \ \varphi\ \ \varphi'\ ]^{\mathbf{T}} \tag{2}$$
$$U = [\ \delta\ ]^{\mathbf{T}} \tag{3}$$

The final result of the identification, after n = 21 data measurements (t = 2.0 s), using a Matlab implemented version of the classic least squares method [3] is the following:

$$[\Phi_{21}\,,\Gamma_{21}]=\begin{bmatrix} 9.5079e\text{-}001 & 3.4779e{+}001 & -1.7931e{+}001 & -1.4134e{+}001 & -1.3064e{+}001\\ 3.8000e\text{-}004 & 8.2254e\text{-}001 & 3.3844e\text{-}002 & 9.5337e\text{-}002 & -1.4376e\text{-}002\\ -1.5513e\text{-}004 & 9.8492e\text{-}002 & 9.3600e\text{-}001 & 6.8752e\text{-}002 & -2.7441e\text{-}002\\ 3.3045e\text{-}004 & 1.5789e\text{-}001 & -2.5812e\text{-}001 & 6.4224e\text{-}001 & -5.3852e\text{-}001 \end{bmatrix} \quad (4)$$

A SIMULINK IMPLEMENTATION

The previous mathematical model is implemented in Simulink-Matlab as shown in **Fig. 3**. This deployed version is more complicate that the state-space model, but has the advantage of a transparent and complete control of the initial values of the state variables.

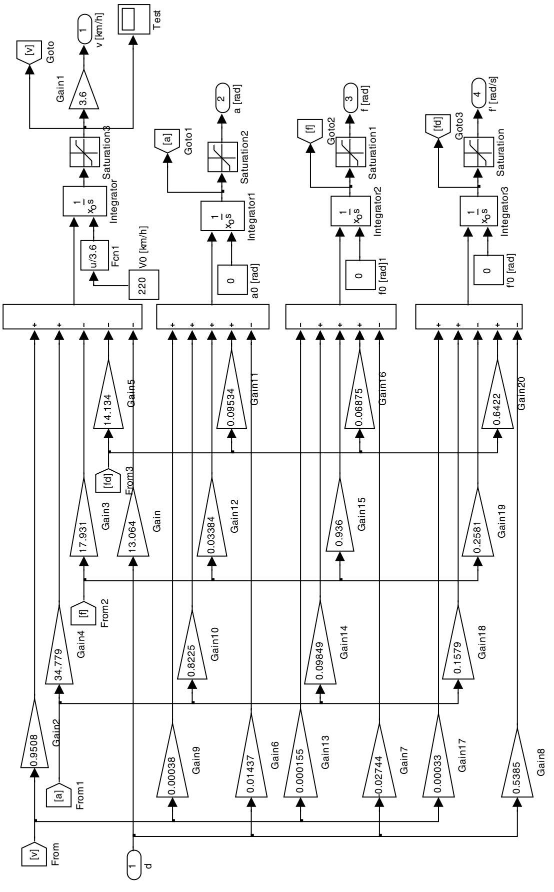

Figure 3. The aircraft longitudinal motion Simulink model

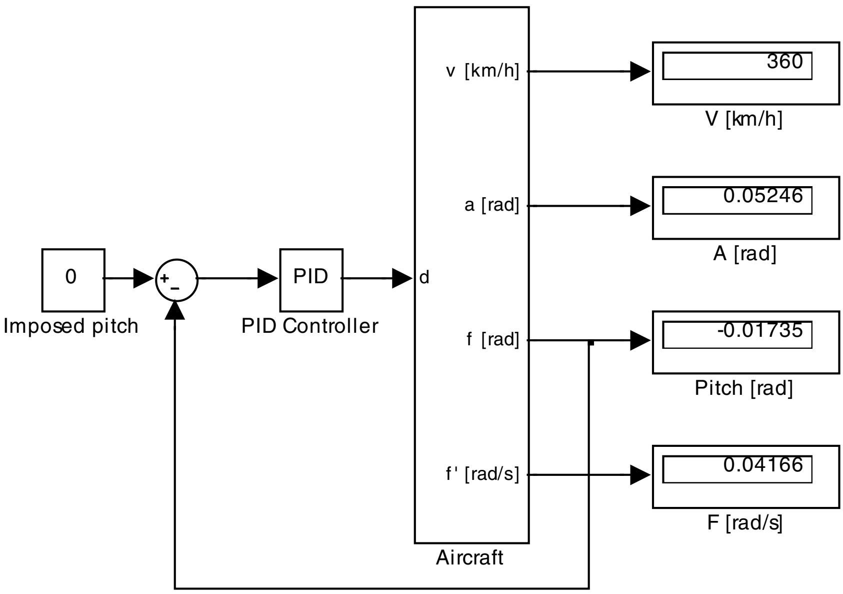

Figure 4. The control of the pitch by the elevator angle

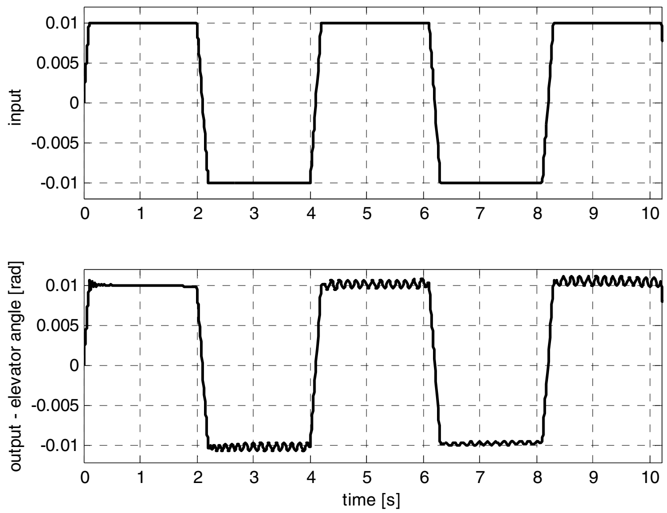

Figure 5. A simulation result

This model can be used now for testing different control algorithms. A simulation result is shown in **Fig. 5**.

The main advantages of this model are the simplicity, the linearity and the accuracy for the given identification conditions. It is adapted for the real-time identification of the specific steady flight regimes.

On the other side its nature is synthetic: no information about the physical structure of the airplane system is included. Although the state variables are physical parameters, they are not able to catch the nonlinear functionality of the system. That is why this model can be hardly used outside of its context.

CONCLUSIONS

The paper is presenting a deployed continuous time version of a state-space mathematical model of the longitudinal motion of an L-410 airplane.

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APPLYING THE CONSTANT TIME TO COLLISION CRITERION IN SWARM SYSTEMS

NOTE: *This paper was presented at the International Symposium "Research and Education in an Innovation Era", Engineering Sciences, November 20-21, 2008, "Aurel Vlaicu" University of Arad, Romania*

ABSTRACT:

The paper is making a short introduction into the field of the swarm intelligent robots and is proposing a new approach for the self-organizing swarms, based on the criterion of the constant time to collision. This criterion is imposing an optimal distance between moving particles, such way that the times to collision between particles are constant, for any speed. The same time to collision is imposed to the whole swarm. The imposed time to collision and therefore the distance gaps between the particles can be adjusted. Such way each member of a moving swarm can find by itself a position that is optimizing the structure and the dimensions of the swarm, according to its speed. A simulation is provided for a simple case: the Indian run.

KEYWORDS:

Swarm intelligent algorithms, particle swarm optimization, constant time to collision criterion.

INTRODUCTION. THE SWARM INTELLIGENCE

The Swarm Intelligent paradigm (SI) [Kennedy and Eberhart 2001, Clerc 2006] is inspired from the social dynamics and emergent behavior that arise in socially organized colonies. The importance of such a concept in the control theory is linked to the idea of the colonies of robots [1], [2], etc. The aim is to replace an individual exploring, working or fighting robot (which is complicate, expensive, and exposed to different failure mechanisms) with a group of much smaller robots (simple, cheap, replaceable), that will act in a self-organized way, inspired by social behavior patterns of organisms that live and interact within large groups. A mathematical concept that is supporting this approach is the Particle Swarm Optimization algorithm (PSO), which may incorporate swarming behaviors observed to birds, fish, bees, ants and even human social behavior [1], [3], [4]. Our purpose is to introduce in swarm systems an optimization criterion that was previously used in the Automate Cruse Control: the Constant Time to Collision (CTTC).

AN INTRODUCTION INTO THE PARTICLE SWARM OPTIMIZATION

PSO is learning algorithm, exploiting a population of individuals to probe promising regions of the search space. In this context, the population is called *swarm* and the individuals are called *particles*. Each particle moves with an adaptable velocity within the search space, and retains a memory of the best position it ever encountered. In the *global* variant of PSO, the best position ever attained by all individuals of the swarm is communicated to all the particles. In the *local* variant, each particle is assigned to a topological neighborhood consisting of a prespecified number of particles. In this case, the best position ever attained by the particles that comprise the neighborhood is communicated among them [4].

Assume a D–dimensional search space, $S \subset \Re^D$, and a swarm consisting of *N* particles. The *i*–th particle is in effect a *D*–dimensional vector $X_i = (x_{i1}, x_{i2}, \dots, x_{iD})^T \in S$. The velocity of this particle is also a *D*–dimensional vector, $Vi = (vi1, vi2, \dots, viD)^T \in S$. The best previous position encountered by the *i*–th particle is a point in *S*, denoted by $P_i = (P_{i1}, P_{i2}, \dots, P_{iD})^T \in S$. Assume *gi* to be the index of the particle that attained the best previous position among all the particles in the neighborhood of the *i*–th particle, and *t* the iteration counter. Then, the swarm is manipulated by the following equations [5]:

$$V_i(t+1) = \chi\,[wV_i(t) + c_1 r_1 (P_i(t) - Xi(t)) + c2\, r2\, (P_{gi}(t) - Xi(t))], \quad (1)$$

$$X_i(t+1) = X_i(t) + V_i(t+1), \quad (2)$$

where $i = 1, \dots, N$; $c1$ and $c2$ are two parameters called *cognitive* and *social* parameters respectively; $r1$, $r2$, are random numbers uniformly distributed within [0, 1], and *gi* is the index of the particle that attained either the best position of the whole swarm (global version), or the best position in the neighborhood of the *i*–th particle (local version). The parameters χ and *w* are called *constriction factor* and *inertia weight* respectively, and they are used as mechanisms for the control of the velocity's magnitude, corresponding to the two main PSO versions. The value of the constriction factor is derived analytically [5]. On the other hand, the inertia weight, *w*, is computed empirically, taking into consideration that large values encourage global exploration, while small values promote local exploration. According to a rule of thumb, an initial value of *w* around 1.0 and a gradual decline towards 0 is considered a proper choice. In general, the constriction factor version of PSO is faster than the one with the inertia weight, although in some applications its global variant suffers from premature convergence. Regarding the social and cognitive parameter, the default values $c1 = c2 = 2$ have been proposed. The initialization of the swarm and the velocities is usually performed randomly and uniformly in the search space, although more sophisticated initialization techniques can enhance the overall performance of the algorithm [4].

THE CONSTANT TIME TO COLLISION CRITERION

As shown before, swarm systems may be abstractized and used in automate learning. In this paper we will come back to the original sense of the concept: swarm system = a group of interacting automobile objects. Our goal is to find an algorithm that is able to optimize the swarm movements, by minimizing the distance between individuals, with respect to a common collision risk. The first step in this direction is to investigate one of the simplest swarm models: the Indian run. The Indian run may be observed in nature at many species of ants, birds, or mammals (elephants for instance), as well as in different social activities, namely in sports: cycling, athletics, etc. We will associate the Indian run to a concept belonging to the Automate cruise control: the Constant Time to Collision (CTTC) criterion [6], [7]. TTC is the time before two following cars (Car2 is following Car1) are colliding, assuming unchanged speeds of both vehicles:

$$TTC = \frac{d_{21}}{v_2 - v_1} \qquad (1)$$

where v_1 and v_2 are the speeds of the vehicles and d_{21} the distance gap between them.

CTTC consists in imposing *stabilized* TTCs by means of the Car2 cruise controller. The on-line TTC control is not convenient because when the two cars have the same speed the TTC's denominator is turning null: v2 - v1= 0. That is why CTTC must be implemented off-line, with the help of $d_i(v2)$ mappings (**fig. 1**). The CTTC implementation by $d_i(v_2)$ distance-gap planners is possible because *a distance gap planner using* TTC *will produce*

CTTC. We studied this method by computer simulations, using a Matlab-Simulink model of the tandem Car1-Car2 [6].

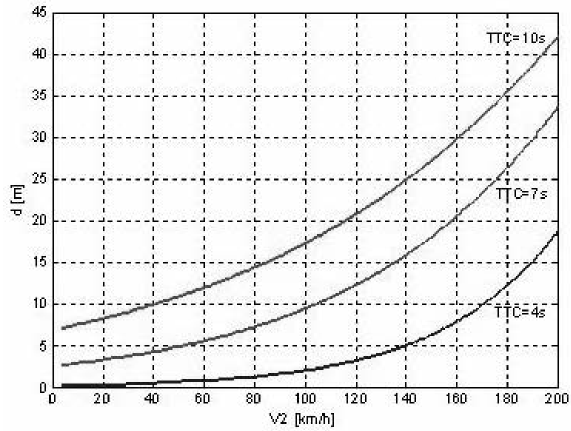

Fig. 1. $d_i(v_2)$ mappings for three different TTC

The distance-gap planners are designed by means of a computer simulation, as follows. The simulation scenario consists in braking Car1 until the car is immobilized, starting from a high initial speed. A TTC controller is driving the Car2 traction/braking force such way that during the whole simulation TTC is stabilized to a desired constant value. The continuous braking allow us to avoid the v_2-v_1=0 case. We will use the recorded d mapping as the desired $d_i(v_2)$ planner for the given TTC. The **Fig. 1** planners are determined for three TTC values: 4s, 7s and 10s. The **Fig. 2** is presenting the computer model.

Applying CTTC brings two obvious advantages:

- a constant collision risk for each vehicle involved;
- the possibility to control the traffic flow on extended road sections, if each vehicle will apply the same TTC that is currently recommended by the Traffic Management Center: a long TTC means *low traffic* flow and *higher safety* while a short TTC means *high traffic* flow and *higher risk*.

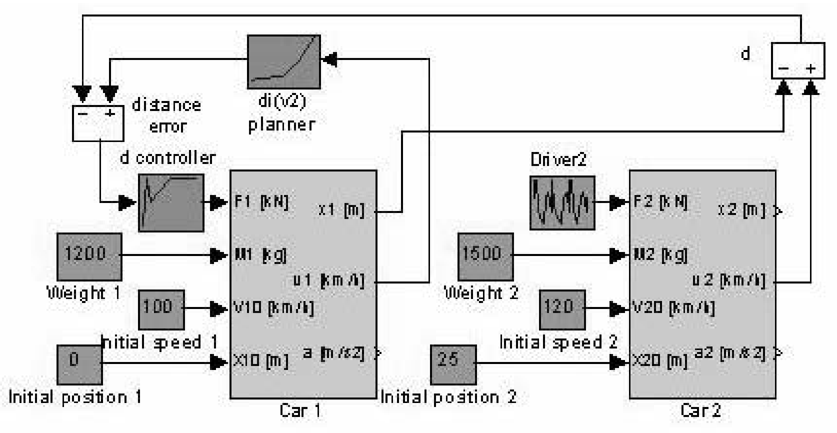

Fig. 2. A cruise control system with distance controller and CTTC $d_i(v_2)$ planner

A CTTC PLATOON SIMULATION

The following Simulink-Matlab model allows us to simulate the behavior of a CTTC platoon, running in Indian style (see Fig. 3). The elements of the platoon are five identical cars, the first one driven by a driver. Each car is provided with a PID distance controller that is following as close as possible the imposed distance di(v), and therefore the imposed TTC. The imposed TTC is variable: 10s for the first 200 seconds of the simulation and 7 s for the last 120 seconds, linked by a ramp transition. All the cars are starting from the same spot.

The speed of the first car, Car1, is presented in Fig. 4. The distances between the cars and the overall length of the platoon are presented in fig. 5. One can easily observe the continuous variation of the platoon's length:

a) with the speed (for the first 200s), and

b) with the imposed TTC (for the last 220s).

Fig. 6 is showing the initialization of the platoon, which is perfectible.

The simulation is illustrating the simplest case of a swarm movement: the longitudinal drive. The next stages of this research should extend the method for the 2D and 3D cases, and refine the control algorithms, that will improve the dynamics of the platoon.

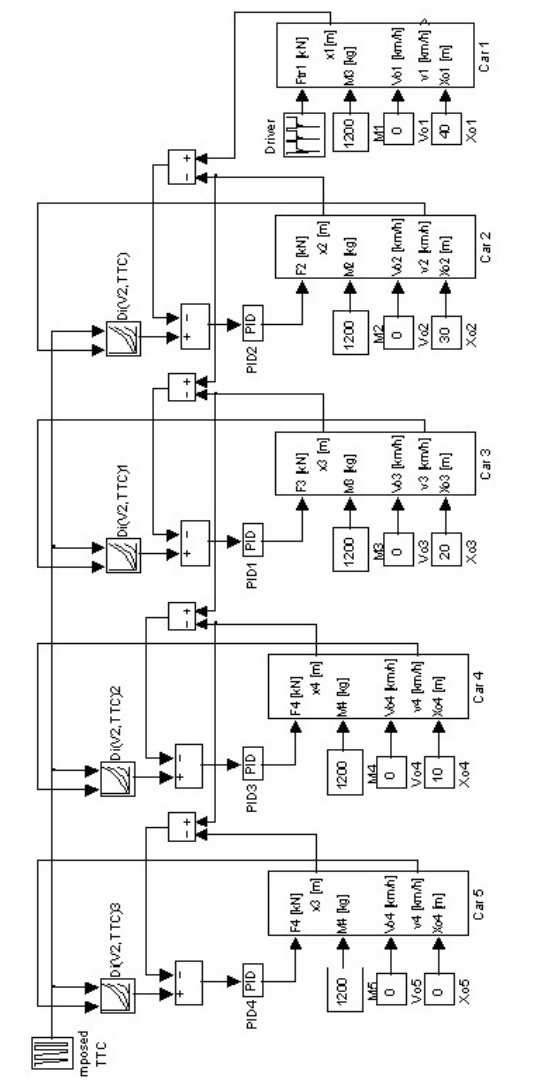

Fig. 3. The Simulink model of a 5 automobiles platoon

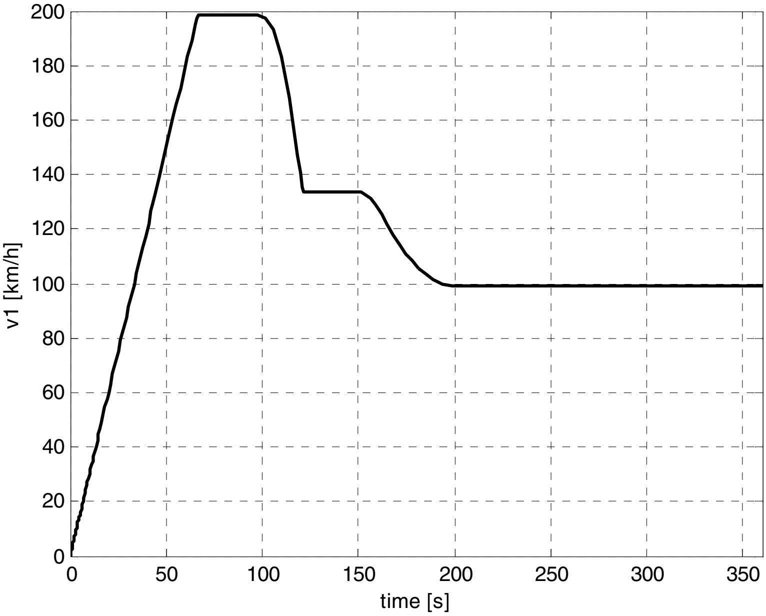

Fig. 4. The speed of the first car

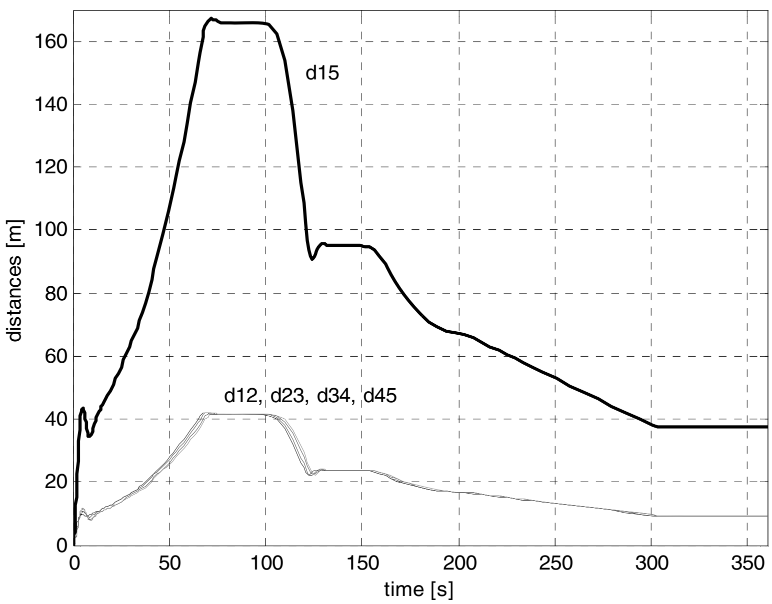

Fig. 5. The distances between cars and the length of the platoon

CONCLUSIONS

The constant time to collision criterion can stand for an optimization method for moving swarm systems. The particles must preserve an optimized distance with their neighbors, such way that the time to collision is constant and adjustable for all the swarm. The distances between particles are continuously adapted to the actual speed and the dimensions of the swarm are minimized. In the same time, the collision risk, that depends of the imposed time to collision is evenly distributed. The method is illustrated by a simulation of an 5 automobiles platoon.

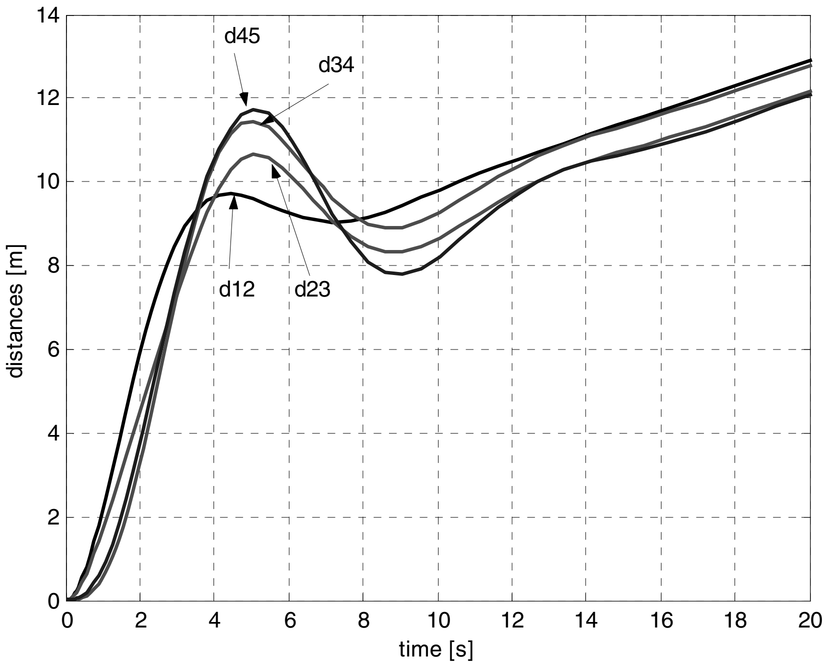

Fig. 6. The initialization of the platoon

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A NEW HEBBIAN-TYPE METHOD FOR SOFT DECISION METHOD

NOTE: *This paper was presented at the International Symposium "Research and Education in an Innovation Era", Engineering Sciences, November 20-21, 2008, "Aurel Vlaicu" University of Arad, Romania*

ABSTRACT:

This article presents an information decision method for information provided by a recognition system composed by two video cameras and two infrared cameras. From each of the video and infrared cameras systems, geometric characteristics are obtained which in are used information fusion. The decision, for determining the label of the object captured in the images is made using a hard type method and a soft type rule by considering an original algorithm based on a modified Hebb-law.

KEY WORDS:

Hebb-law, hard decision method, soft information

INTRODUCTION

The complexity of the captured images, and the numerous parameters that can influence the localization and recognition in images determined the appearance of numerous articles, which propose a vast number of methods [1, 2]. One issue of this subject is to improve the rate of correct recognition using information fusion. It was proposed numerous fusion methods, each having advantages in different situations. But in the end it must be made a decision to relate or not the unknown object with one prototype or cluster. It can be use a hard decision in which every input has a well definite value, or for improving the correct labeling process it can be made a decision, not only on one information fusion results, but based on a set of information fusion, which can be adaptive. This means that the decision can be computed taking in relation different types of fusion, hopefully having different theoretically fundaments and the importance of every fusion method on the result can be based on the past experience. Applying this point of view it can be obtained an adaptive algorithm.

DECISION METHOD

The decision which is determined in this article is used for establishing recognition of an object, using a video and an infrared camera set. From the geometrical characteristics obtained by processing the images, a set of information fusions are determined. The algorithms use for obtaining the results are: heuristic fusion, fuzzy fusion and reinforce fusion [3, 4] denoted respectively with μ_i $(i \quad \{E, F, C\})$. This fusion results are fuzzy numbers, having more accurate information contains. The reason of using these methods is based on the different theoretical fundaments of these information fusions.

Taking a decision implies a set of inputs, a method and an output which usually is a binary type number, meaning the acceptance or not of the decision. The inputs can be crisp numbers, which determine a specific method, like voting, median result or average determination. The problems with this type of inputs are that is a rigid one, information being lost in the process of inputs determination, (like the fusion results in this experiment). In the case of using soft decision methods, it can be conserved the entire information of the inputs by including both the value and the membership value obtained from the fusion process. In our experiments, for evaluation, we used a hard decision method and a soft adaptive method

2.1. Hard method

This method is based on majority type decision. First, the three information fusion results are convert to crisp numbers D_i by comparing the membership of this values μ_i ($i \quad \{E, F, C\}$) to a threshold θ, (which is usually ½). The final decision is obtained using the relation (1).

$$D_H = \begin{cases} 1 & card\,(D_i = 1) \quad \{2;3\} \\ 0 & card\,(D_i = 1) \quad \{0;1\} \end{cases} \qquad (1)$$

where D_H represents the hard type of decision.

2.2. Soft method

The soft decision is based on a reverse type of approach. First is made the decision, and only in the end is determined the crisp result. That means that is used of the weigh sum of the fusion results memberships, as is presented in relation (2).

$$D_S = \begin{cases} 1 \mid (a \cdot \mu_E + b \cdot \mu_F + c \cdot \mu_C \geq \theta \\ 0 \mid (a \cdot \mu_E + b \cdot \mu_F + c \cdot \mu_C < \theta \end{cases} \qquad (2)$$

where $a,b,c \quad [0;1]$ are the weigh constants, and the following relation must be satisfied: a+b+c=1

Similar to the method used in hard decision, θ, is a threshold applied for obtaining the crisp number. Usually, is used a value = ½., which corresponds to the maximum uncertainty [6].

The weigh constants are obtained by an iterative method, by tuning these values using a learning process based on comparing the obtain result with the real situation. Soft decision can be obtained using another method for determining the constants, based on Hebb type learning. This procedure applied in artificial neural networks, is based on the reinforcement of the most used constants.

In this case is used the following relation (3) (see [5]):

$$w_{ij} = \alpha \ \ y_j \ \ x_i - \phi \ \ y_j \ \ w_{ij} \tag{3}$$

where x_i , y_j is the i input and respectively j output, w_{ij} is the weight of mutual connection, and α , ϕ represents the learning and respectively the forgetting constant used in the learning process The new relation proposed in this article is:

$$\Delta coef_i^t = \alpha \cdot D_i - \phi \cdot \varepsilon_i \tag{4}$$

where i $\{E, F, C\}$,
and

$$coef_i^t = \begin{cases} a^t \mid i = E \\ b^t \mid i = F \\ c^t \mid i = C \end{cases}$$

The constants a, b and c are obtained by updating at t+1 period of time the previous constants used in moment t. Also it must be done a normalization operation in order to maintain the constants sum equal with one.

In order to obtain the constant a, by applying this new method, it will be used the following relation

$$a = \frac{a^{t+1}}{a^{t+1} + b^{t+1} + c^{t+1}} \quad (5)$$

where

$$a^{t+1} = a + \quad a^{t} \quad (6)$$

Constants *b* and *c* are obtained using similar relations.

Similar with the original Hebb artificial neural network method the learning and the forgetting constants will take the following values α = 0,1, respectively ϕ = 0,01,which had be proved to conduct to the best results in the testing process.

It must be observed that even if in this article the two above mention constraints have kept the original names from the Hebb method, in this new relations, it have different meaning, adapted to the decision process. Thus, the α constant is used to weight the right decision, increasing the influence of the specified fusion method. Similar, the ϕ constant is used to decrease the weight of the fusion method, reflecting the influence on the result of the errors.

CONCLUSIONS

For images recognition we have proposed a decision method system composed by two video cameras and two infrared cameras. This system is used for computing three information fusion results, based on: a heuristic method, a fuzzy method and a reinforcement method, which were selected because having different theoretical bases. For each of video and infrared cameras systems, geometric characteristics are obtained which are used in the three types of information fusion.

As a first result of this article, based on the results obtains from these three fusion methods, is proved that the soft decision method is better performing that the hard decision method.

Based on this conclusion it was taken in consideration a new soft decision method, by using a modified Hebb-law. This adaptation of an artificial neural network to a decision method has proved that by using a training based constants it can be improved the decision results. The results are explained because this type of method increase the influence of the better fitting fusion method, for various real conditions

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THE PHASES OF AUTOMATIC CLASSIFICATION OF VEGETAL PRODUCTS THROUGH MACHINE VISION TECHNIQUES

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ABSTRACT:

Shape, colour and size represent the main parameters of vegetal products to assess with view to classifying them. These parameters may also be turned to good account by the machine vision techniques that proved to be applicable in several domains. One can especially apply these techniques in the inspection and analysis systems of industrial products where the parameters vary according to very low limits.

Taking into account these facts one has tried to develop a classification system of vegetal products based on machine vision techniques, as well as on decisive algorithms belonging to the artificial intelligence: neural networks and Fuzzy algorithms. The phases of the classification process of vegetal products together with a port of the soft applications developed as well as some of the results obtained are presented in details.

KEYWORDS:

machine vision, shape, colour, classification, image processing, neural network, fuzzy logic.

INTRODUCTION

Over the last 30 years, there has been a higher and higher interest focused on the problems of recognition and identification of surfaces and image processing, via machine vision techniques. Using these new technologies in developing classification systems of industrial products brought about various benefits such as: doing away with inconsistency and the dependence on human/manual labour, raising accuracy and labour speed. Focusing on these premises, over the last 10 years, several studies and researches have been carried out that hint to the adjustment of both these techniques and the image processing algorithms to the particularities of vegetal products classification.

Thus, Meyers (1988) presented in a paper the advantages and disadvantages of using human operators in the inspection and classification process of vegetal products, while Deck (1999) pointed out to the disadvantages of using a semi-automatic sorting. The importance of using non-destructive techniques in the process of classifying vegetal products, based on video inspection has been also stated by Baoping (1999), while Laykin (2002) presents a classification system of tomatoes according to the shape and colour. On a classification device for apples Sudhakara (2002) be presents and validates a series of identification algorithms of colour and shape, by mixing up image pre-processing techniques with the algorithms belonging to the artificial intelligence neural networks. The colour, shape, size and surface defect of fruit are important features in classification. For all these reasons a series of algorithms has been developed which, on the basis of shape and colour descriptors, are supposed to establish the degree of health, size and colour of the vegetal products by using neural networks and Fuzzy algorithms as using neural networks and Fuzzy algorithms as part of the decisive algorithms.

THE EXPERIMENTAL DEVICE THE „MACHINE VISION" SYSTEM

The device of video-inspection has been carried-out around transporters with a belt activated by an electric engine, which ensures the moving of the product in face of the video-inspection system, made of two video cameras with manual focusing.

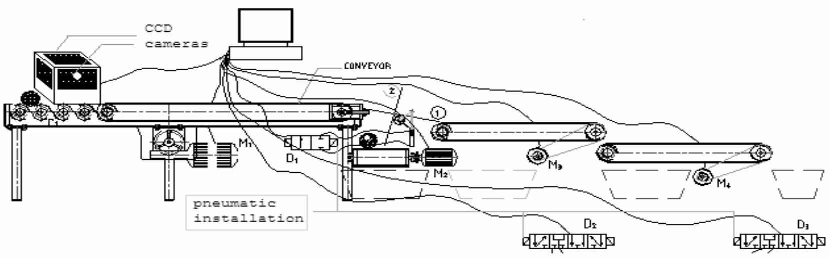

Figure 1. Conveyor and device of video-inspection

The cameras are disposed in the same frame, realizing an angle of 600, towards the analyzed object. These allow the acquisition of 4 coloured RGB pictures of 512*512 pixels, which they transmit in a real time, to the analyzing mechanism represented by a PC of Pentium IV/3200 MHZ type.[2][3] The illumination system represents an essential component part of a „machine vision" classification system.

TRAINING THE DECISIVE ALGORITHMS AND ESTABLISHING THE VARIATION FIELDS FOR EACH TYPE OF PRODUCTS

The applications based on the visual inspection of products and mostly of vegetal products require a high degree of interactivity with the user. This interactivity mainly prevails during the training and identification phase of the variation fields for size and dimension, corresponding to each type and caliber. Taking into consideration all these premises, an application called. Fields Analizor has been projected and then developed allowing to identify in real time the most important parameters for the classification processes. The way of functioning as well as the structure of the application is presented in diagram UML, presented in **Fig.2**, a diagram that was at the origin of carrying out the application.

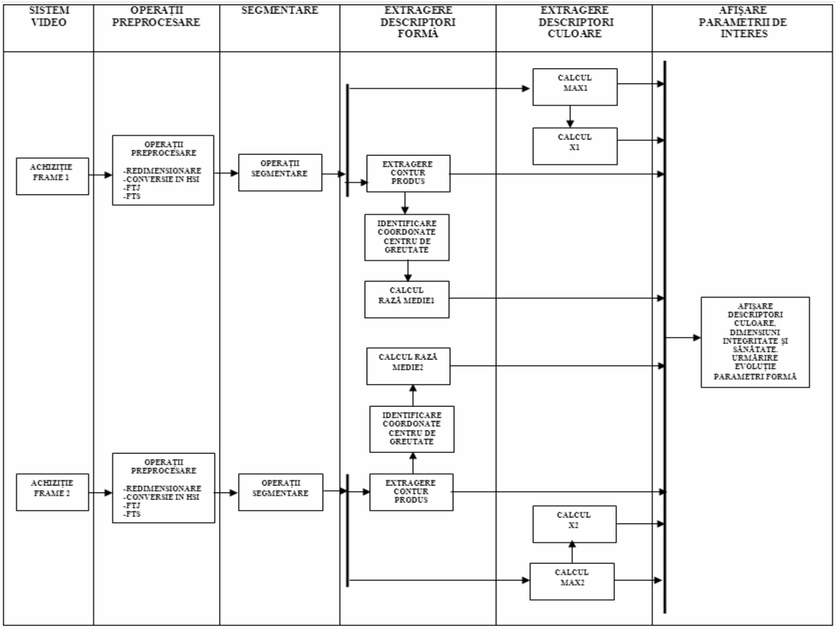

Figure 2. Diagram UML according to the colour of activities for the process of training and identification of the variation fields of colours and dimensions

In **Figure 3**, the interface of the application Fields Analizor is presented in the sections “Colour” and “Dimensions” the values of parameters corresponding to the products under analysis are this time presented while in the sections “Shape descriptors” the values of the vectors while are to be used in the neural algorithm of setting the products integrity in the training phase, are extracted.

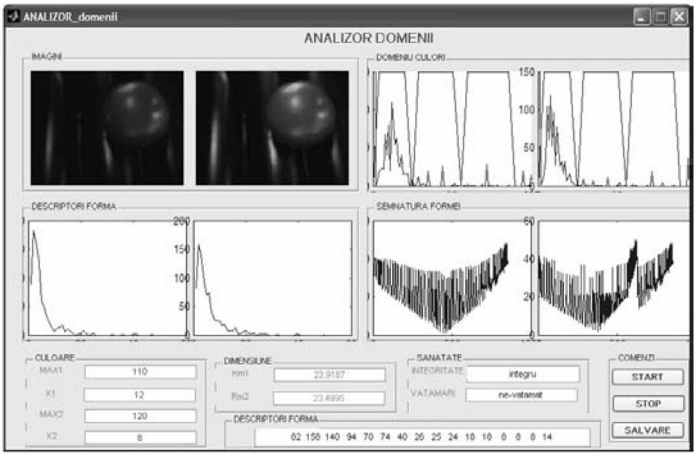

Figure 3. The interface of the application Fields Analizor used during the training and identification phase of the variation fields for each class of products.

Since the shape of product, that is its integrity, is difficult to asses from the 16 shape descriptors displayed, the operator has also access to two graphic representations: the evolution of the "Shape descriptors" and "The Signature of the shape".[3]

THE PRESENTATION OF THE APPLICATION IMAGE ANALIZOR OF CLASSIFYING THE PRODUCTS

Considering the features of both vegetal products and the requirements, the projection of the application **Image Analizor** was carried out on the basis of the diagrams UML, while the activity diagrams of the process out up according to their colour, were presented in **Figure 4**.

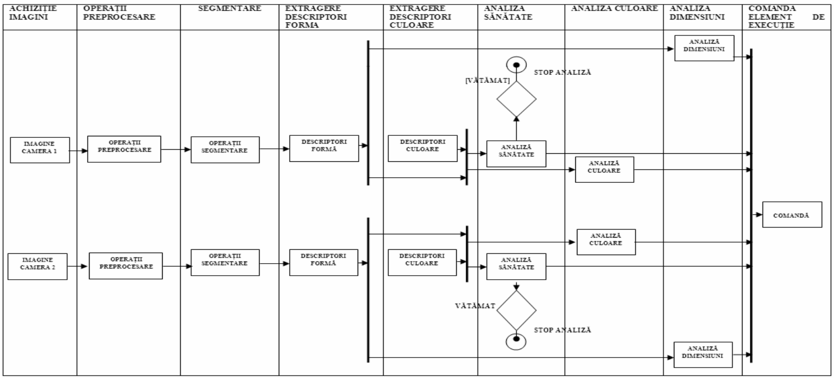

Figure 4. Diagram UML of the command process according to the colour of activities

The interface of the application (**Figure 5**) is very simple and it directly leads the operators to the goals of the process the greatest amount of information regarding the colour, size and the health degree, as cared to the images belonging to the product under analysis. Thus, the operator has the opportunity to stop the functioning of the installation if he has any doubts concerning the correctness of the application decisions.

Figure 5. The interface of the application Image Analizor

The projected application is giving for analysis four images of the some product, two – two at about 1 second from each other. The lapse of time between the two acquisitions of images may be set by the user according to the speed of the conveyor as part of the function "Button - Acquisition". The four images acquired are subjected to the improving operations and then, on the basis of the shape and colour descriptors, they are going to be classified according to their degree of health, colour and size. In order to meet the demand of accuracy for the image processing algorithms, the latter have been projected so as to roll throughout the frequency field, and only during the last, decision – taking phase, are they supposed to operate in the special field.

RESULTS AND DISCUSSION

For the training phase, 3 sets of tomatoes have been used. Thus, the first set was composed of 30 tomatoes and it was used to establish the dimensional limits. The affiliation of the tomatoes to the three classes: big, medium and small was materialized by a human operator, ten tomatoes for each of them. The second set was composed of 30 tomatoes as well, ten for each class: ripe (red) medium ripe (pink), unripe (green), while the third set – 15 products, ten of them healthy and the other five having various faults. In order to test the algorithms and the applications projected and carried out, 15 tomatoes of different colours and health degrees have been used, but they belonged to the same type of tomatoes used during the training phase. The results obtained after the test were 100% concerning the accuracy of assessing the colour, 100% concerning the accuracy of assessing the size and 90% when assessing the health degree.

CONCLUSIONS AND FUTURE WORK

After the test the following conclusions have been formulated:

The algorithms projected for the identification of the ripeness degree, the size and the health degree, based on the analysis of the rays signature and the average of the hue, are very efficiently used as combined to the Fuzzy logic and the neural networks.

Taking into account the numberless amount of forms that the vegetal products can have, the utilization of the classificatory of neuronal type can be considered an important alternative (in comparison with the rest of the techniques of classification).

In the training process of the decision algorithms, based on neural networks, the set of products chosen for training plays a very important part. Thus, chosing an inappropriate set may lead to serios errors in the process of classification.

The fuzzy algorithm, despite of its simplicity, turned out extremely well and was very fast and easily implemented. It is expected to function as well when increasing the number of classes.

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FORMALIZATION OF POINT OF VIEW BY THE FUZZY SET THEORY

ABSTRACT:

A point of view pv may bedefined as a couple pv =(D,) where D is a set whose elements are called determinants and is a mapping from D into[0,1]. The mathematical results in the theory of fuzzy sets permit us to have many constructions of different points of view. We can also compare two points of view by introducing the notion of imbrication and dissimilarity.

KEYWORDS:

point of view, determinant, taking into consideration, degree, fuzzy set.

1. INTRODUCTION

The purpose of this paper is to introduce the possibility to give a mathematical formalization of point of view. It permits us first to combine different points of view by mathematical operators and then to ratify the result of mathematical operation by comparison with our intuitions or experiences.
As our investigation object is imprecise or fuzzy, we choose the fuzzy set as domain of mathematical formalization. In effect, the theory of fuzzy set is actually developed and may be used in different domains, so that it seems useful to us to exploit the possibility of this theory in order to manipulate and control the points of view and their different combination beyond our intuition.
Thus mathematical formalization of point of view founded on the theory of fuzzy set shows that it is possible to manipulate the fuzzy sets and to applicate them to humain thoughts.
This paper is organized as follows. After a brief recalling of the fuzzy set theory in the section 2, we introduce in the section 3 the notion of point of view. The section 4 is devoted to different operations on the points of view. Then we describe, in the section 5, the mathematical formalization of the similarities of point of view. Finally we conclude our paper in the section 6.

2 FUZZY SET

The previous consideration permits us to explain the reason of using the theory of fuzzy set. Let X an universal set.

Definition 2.1 *A fuzzy set of support $A \subset X$ is the data of the couple (A, α) where α is a mapping from A to* $[0,1]$. *α is called membership function. For $x \in A$, $\alpha(x)$ represents the degree of membership of x to A.*

Remark 2.1 *The degree of membership of an element x doesn't belong only to the pair* {0,1} *like in a classical theory of set but it belongs to* [0,1]

• *If* $\alpha(x)=0$, *x doesn't belong at all to A.*

• *If* $\alpha(x)=1$, *x belongs completely to A.*

• *If* $0 < \alpha(x) < 1$ *the membership of x to A is more or less complete.*

Remark 2.2 *The mathematical result given by the theory of fuzzy set permits to have many constructions and combination of different points of viev from the set operators: union, intersection, inclusion, which may be confronted with what we think or feel.*

3 POINT OF VIEW

We begin by giving a definition of point of view with some simple hypothesis.

Definition 3.1 *A point of view pv is determined by a couple pv =(D, α) where D is a set whose the elements are called determinants and α is a mapping from D into* [0,1].
If $d \in D$, $\alpha(d)$ *represents the taking into consideration for the d by the point of view pv.*
We assume that the following hypothesis are satisfied:

• ***H1:*** *A point of view is specified by a set of determinants that it take into consideration.*

• ***H2:*** *Those determinants are of different natures: criterion, indicator, rule, constraint, aspect,... That can put in relation to a measure or some evaluation..*

• ***H3:*** *Those determinants are taken into consideration by point of view with varied degree.*

We denote by $D = \{d_i, i \in I\}$ the set of determinants of point of view in one given context, that we don't give some precision in this step. Therefore D is a set in the classical sense.
Twopoints of view $pv_1 = (D_1, \alpha_1)$ and $pv_2 = (D_2, \alpha_2)$ may bedistinguished oneself of two manners:

• The first distinction replace on the set difference between D_1 and D_2.

• The second distinction replace on the related importance of taking consideration of one determinant by the point of view pv_1 and pv_2.

Example 3.1 *Let* $pv_1 = (D_1, \alpha_1)$ *and* $pv_2 = (D_2, \alpha_2)$ *with* $D_1 = D_2 = D$ *= lowground, forest, grassland, fallowfield*
Suppose that one does a survey about the importance of these determinants. Let α_1 *the result of rural survey and* α_2 *the result of urban survey: Let be* d_1 *= lowground,* d_2 *= forest,* d_3*=grassland,* d_4 *= fallowfield.*

$\alpha_1(d_1) = 0.7$; $\alpha_1(d_2) = 0.4$; $\alpha_1(d_3) = 0.5$; $\alpha_1(d_4) = 0.4$;

$\alpha_2(d_1) = 0.5$; $\alpha_2(d_2) = 0.8$; $\alpha_2(d_3) = 0.4$; $\alpha_2(d_4) = 0.3$;

In this example, we have $\alpha_1(d_1) \geq \alpha_2(d_1)$; *that means that determinant* d_1 *is more taken into consideration by* pv_1 *than* pv_2*, or* $d1$ *is more important for rural people than for town-dweller.*

Notation:

	d_1	d_2	d_3	d_4
α_1	0.7	0.4	0.5	0.1
α_2	0.5	0.8	0.4	0.3

4. OPERATION OF POINTS OF VIEW

Let $pv_1 = (D_1, \alpha_1)$ and $pv_2 = (D_2, \alpha_2)$, two points of view, the operations between these two points of view concern both D_i and α_i.

4.1 Inclusion

The inclusion of two points of view $pv_1 = (D_1, \alpha_1)$ and $pv_2 = (D_2, \alpha_2)$ is denoted by $pv_1 \subset pv_2$, if $D_1 \subset D_2$ and for all $d_1 \in D_1$, $\alpha_1(d_1) \leq \alpha_2(d_2)$

4.2 Intersection and T-norm

4.2.1 Intersection

The Intersection of two points of view $pv_1 = (D_1, \alpha_1)$ and $pv_2 = (D_2, \alpha_2)$ is denoted by $pv_1 \wedge pv_2 = (D_1 \cap D_2, \alpha_1 \wedge \alpha_2)$, where $\alpha_1 \wedge \alpha_2$ is the infinimum of α_1 and α_2, (ie) for all determinant d in $D_1 \cap D_2$, $\alpha_1 \wedge \alpha_2(d)= \inf(\alpha_1(d), \alpha_2(d))$.

4.2.2 T-norm

The taking into consideration of determinants at once by pv_1 and pv_2 which gives us the point of view $pv_1 \cap pv_2$ can be proceeded by different manners beyond using the infinimum. TheT-norms are tools that combine pv_1 and pv_2 otherwise in order to have an other type of intersection that we denote always by $pv_1 \wedge pv_2$

Here are some examples, that are more used in the theory of fuzzy set to express the intersection of α_1 and α_2 that we denote always by $pv_1 \wedge pv_2$

• min operator: $min(1(d),2\ (d))$

• algebraic product $\alpha_1 \cdot \alpha_2(d) = \alpha_1(d) \cdot \alpha_2(d)$

• limited product $min(1,(\alpha_1\ (d) + \alpha_2(d)))$

• drastic product $\begin{cases} \alpha_2(d)\_if\ \_\alpha_1(d) = 1 \\ \alpha_1(d)\_if\ \_\alpha_2(d) = 1 \\ 0\_\_\_\_if\ \_\alpha_1(d)\_and\ \_\alpha_2(d) > 0 \end{cases}$

• Einsten product: $\dfrac{\alpha_1(d) \cdot \alpha_2(d)}{2 - \alpha_1(d) - \alpha_2(d) + \alpha_1(d) \cdot \alpha_2(d)}$

• Hamasher product: $\dfrac{\alpha_1(d) \cdot \alpha_2(d)}{\alpha_1(d) + \alpha_2(d) - \alpha_1(d) \cdot \alpha_2(d)}$

These T-norm considered have no parameters by they could have one.

4.3 Union and T-co-norm

4.3.1 Union

The union of two points of view $pv_1 = (D_1, \alpha_1)$ and $pv_2 = (D_2, \alpha_2)$ is denoted by $pv_1 \vee pv_2 = (D_1 \cup D_2, \alpha_1 \vee \alpha_2)$, where $\alpha_1 \vee \alpha_2$ is the supremum of α_1 and α_2, (ie) for all determinant d in $D_1 \cup D_2$, $\alpha_1 \vee \alpha_2(d) = sup(\alpha_1(d), \alpha_2(d))$.

4.3.2 T-co-norm

The taking into consideration of determinant by pv_1 and pv_2 which gives the point of view $pv_1 \vee pv_2$ can be processed by different manners otherwise on using supremum.

The T-co-norm are tools which combine $pv_1 \vee pv_2$ in order to have an other type of union. Here are some examples :

• max operator: :$max(\alpha_1(d), \alpha_2(d))$

• algebraic sum: $\alpha 1(d) + \alpha_2(d)$

• limited sum: $max(0, \alpha_1(\mathrm{d}) + \alpha_2(d) - 1)$

• drastic sum: : $\begin{cases} \alpha_2(d)\_if\_\alpha_1(d)=0 \\ \alpha_1(d)\_if\_\alpha_2(d)=0 \\ 1\_\_\_\_if\_\alpha_1(d)\_and\_\alpha_2(d)>0 \end{cases}$

• Einstein sum: $\dfrac{\alpha_1(d)+\alpha_2(d)}{1+\alpha_1(d)\alpha_2(d)}$

• Hamasher sum: $\dfrac{\alpha_1(d)+\alpha_2(d)-2\alpha_1(d)\alpha_2(d)}{1+\alpha_1(d)\alpha_2(d)}$

• disjunctive sum $max(min(\alpha_1(d),1-\alpha_2(d)), min(1-\alpha_1(d), \alpha_2(d)))$
The operators of T-co-norm considered here have no parameters but they could have one.

4.4 Complementarity

The complementarity of pv_1 is denoted by $pv_1^c = (D_1, 1-\alpha_1)$

Remark 4.1 *Let* $pv_1 = (D_1, \alpha 1)$ *a point of view.*

• $i - pv_1 \wedge pv_1^c \neq \phi$

• *ii – The complementarity concept here means that if pv_1 takes account one determinant with x percent so then pv_1^c takes account with* (1 - *x*) *percent.*

• *iii - The remarks 1 and 2 induce us to say that there is a kind of imbrication between the point of view pv_1 and his complementarity pv_1^c which we define later in **4.5***

• *iv – The concept of complementarity with regard to determinant considered or not is taken into account by the previous definition with the following manner:*

One determinant, which is not taken into account, has a degree of taking into account equal to zero. For example, if one determinant $d_1$is not taken into consideration by one point of view pv_2, his degree of taking into account is zero; in other hand, if one determinant d_2 is not taken into account by the point of view pv_1, then it has a degree of taking into account zero, but if it is taken into consideration with a degree upper by pv_2, then the point of view pv_1 and pv_2 are complementary with regard to determinants d_1,d_2.

4.5 Cuts

The concept of cuts for a point of view $pv = (D, \alpha)$ permits to show the set of determinants *d* in *D* which are taken into account by *pv* beyond a certain choosen degree. Let be $r \in [0,1]$. We denote that *r*-cuts of point of view *pv* the point of view $pv_r = (D_r, \alpha)$ such that $D_r = \{d, d \in D/(d) \geq r\}$, D_r is a set included in *D*. A *r*-strict cuts is r defined by $pv^r = (D^r, \alpha)$ such that $D^r = \{d,d \in D/\alpha(d) > r\}$,

Property 4.1 *Let be* $r \in [0,1]$
i – $(pv_1 \cap pv_2)^r = (pv_1)^r \cap pv_2)^r$
ii – $(pv_1 \cup pv_1)^r = (pv_1)^r \cup (pv_2)^r$.

iii – $(pv^c)_r = pv^c_{1-r} \neq pv_r$ *if* $r \neq ½$ *and* $r \neq 1$.

4.6 Size of points of view

The size of point of view *pv* is defined by $|pv| = \sum_{d \in D} (\alpha(d))$

If *D* is finite the relative size of point of view is $\|pv\| = \frac{|pv|}{CardD}$

If the set of determinant is continuous that we denote by X, the relative size is defined by $|pv| = \int_D \alpha(x)dx$.

4.7 Imbrication between two points of view

In this, section, we can say about the imbrication between two points of view . In fact, in the classical theory of sets, we have one of two relations inclusion A ⊂ B or B ⊂ A.
The two relations are mutually exclusive. But in the theory of fuzzy set if A ⊂ B, B can be embedded partially in A. The imbrication of B in A is graduate. If A is in B then the degree of imbrication of A in B is equal to 1. If A∩B = ∅; the degree of imbrication is equal to zero.

Thus, we denote that the degree of imbrication of pv_1 in pv_2 by:

$$I(pv_1, pv_2) = \frac{|pv_1 \cap pv_2|}{|pv|}$$

Definition 4.1 *Let* $pv = (D, \alpha)$, *we call the support of pv the subset supp(pv)* = $\{d \in D / \alpha(d) \neq 0\}$

4.8 Entropy of point of view

Let us remark that: *supp(pv)* ∪ *supp(pv)*^{c} ≠ *D* and *supp(pv)* ∩ *supp(pv)*^{c} Ø;. This shows the fact that there is an overlap between *pv* and pv^c or in other word, there is a certain disorderin *pv*. The measure of this disorder is expressed by the entropy concept and for all *pv* that we denote by:

$$E(pv) = \frac{|pv \cap pv^c|}{|pv \cup pv^c|}$$

4.9 Distance between two points of view

Here, we consider two points of view which have the same set of determinants *D*, even if some determinants are not taken into consideration by one or other point of view . Let $pv_1 = (D, \alpha_1)$ and $pv_2 = (D, \alpha_2)$, the distance between two points of view is a tool which permits to evaluate the difference between them. It exists many types of distance but here, we are interested by the Hamming distance and Euclidean distance.
In the finite case, we define:

• Hamming distance : we define the Hamming distance between $pv_1 = (D, \alpha_1)$ and $pv_2 = (D, \alpha_2)$ by:

$$d(pv_1, pv_2) = \sum_{d \in D} |\alpha_1(d) - \alpha_2(d)|$$

• Euclidean distance: The euclidean distance between $pv_1 = (D, \alpha_1)$ and $pv_2 =(D, \alpha_2)$ is defined by:

$$d(pv_1, pv_2) = \sqrt{\sum_{d \in D} (\alpha_1 d - \alpha_2 d))^2}$$

5. DISSIMILARITY AND SIMILARITY

Let D a set of determinants, let us denote by PV the set of points of view $pv_i = (D, \alpha_i)$, $i \in I$. In order to compare the points of view which have the same set of determinants, we introduce the notion of dissimilarity between two points of view

Definition 5.1 *A mapping* $ds : PV \times PV \rightarrow [0,1]$ *is a dissimilarity if and only if:*

• *For all* $pv \in PV$, $ds(pv, pv)=0$

• *For all couple* $(pv_1,pv_2) \in PV \times PV$, $ds(pv_1, pv_2) = ds(pv_2, pv_1)$

Such mapping permits to measure the degree of dissimilarity between two points of view .
In dual manner,we can measure the degree of similarity between two points of view by a mapping: $s : PV \times PV \rightarrow [0,1]$ which satisfies the following conditions:

• For all couple $(pv_1, pv_2) \in PV \times PV$, $s(pv_1, pv_2) = s(pv_2, pv_1)$

• For all $pv_1, pv_2, pv_3 \in PV$, $s(pv_1, pv_2) \leq s(pv_3, pv3) = 1$

Thus, we can associate to all dissimilarity ds a similarity s defined by: $s = 1- ds$

Example 5.1 *Let us consider*

$$ds(pv_2, pv_1) = \frac{\sum_{d\in D} |\alpha_1(d) - \alpha_2(d)|}{\sum_{d\in D} \max(\alpha_1(d), \alpha_2(d))} \Rightarrow s(pv_2, pv_1) =$$

$$= 1 - \frac{\sum_{d \in D} \left|\alpha_1(d) - \alpha_2(d)\right|}{\sum_{d \in D} \max(\alpha_1(d), \alpha_2(d))}$$

We can verify easily that ds is a dissimilarity and *s* is a similarity.
Let us consider the previous example in **3.1.**

	d_1	d_2	d_3	d_4
α_1	0.7	0.4	0.5	0.1
α_2	0.5	0.8	0.4	0.3

We can calculate the dissimilarity between the two points of view, we get pv_1 and pv_2.

$ds(pv_2, pv_1) = 0.39 \Rightarrow s(pv_2, pv_1) = 0.61$.

Therefore we can conclude that the point of view of the town-dweller and the rural people, about the different varieties of earth are not similar for $s(pv_2, pv_1)$ is strictly inferior to 1.

CONCLUSION

The present work permits us to enlarge into an interval $[0,r] \subset [0,1]$ the values of taking into account criterions by a point of view instead of $r \in [0,1]$. That amounts to replacing the value point r of [0,1] by an interval, i.e by a set of infinite cardinal but measurable $[0, r]$, included in [0,1]. Thus, it consists to hang up the points of view to the theory of fuzzy sets which permits to graduate the equality in addition to the graduation of membership.
In the next time, we project to link up the points of view with the category theory, in particular with the "topos theory", via the theory of fuzzy sets. The points of view will be manipulated by the procedure of category construction, under existence

conditon. This second step tries to answer to our preoccupation for connecting the point of view and the transcendence to the process of human rational understanding in order that thepoint of view and the transcendence would notbedifficultfor the reason to understand them.

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