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## CHANGING ATTITUDE PATTERNS IN GROUP DECISION MAKING PROCESS – A SOCIO-TECHNOLOGICAL APPROACH

### WZORCE ZMIANY ZACHOWAŃ W PROCESIE PODEJMOWANIA DECYZJI W GRUPIE – PODEJŚCIE SOCJOLOGICZNO-TECHNOLOGICZNE

#### Abstract

This paper proposes a novel approach to consensus reaching process, which combines a mathematical model and socio-psychological factors. We attempt to correlate two decision support systems: one with the teacher managing the process of reaching consensus within the laboratory groups of individuals, and computer-based system, with mathematical presumptions as for the consistency of the model with the reality of a particular social group.

*Keywords: motivation, consensus, attitude patterns, opinion changing, influence matrix, decision support systems, fuzzy preference relations*

#### Streszczenie

Przedmiotem niniejszego artykułu jest nowatorskie podejście do procesu osiągnięcia konsensusu, łączące matematyczny model z czynnikami społeczno-psychologicznym. Autorki podjęły się próby skorelowania dwóch systemów wspomagania decyzji: rzeczywistego z nauczycielem zarządzającym procesem osiągnięcia konsensusu w laboratoryjnych grupach studentów, a także informatycznego, którego matematyczne założenia były zgodne z realnymi zachowaniami określonej grupy społecznej.

*Słowa kluczowe: motywacja, konsensus, wzorce zachowań, zmiana opinii, macierz wpływu, systemy wspomagania decyzji, rozmyte relacje preferencji*

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## 1. Introduction

Group decision making process is a highly diverse process relatable to multitudinous spheres in life, ranging from everyday life decisions to scientific research. The process has been developing in academic and nonacademic environments throughout centuries, with contributions coming from versatile cultural and social milieus. As the aim of this paper is to focus on a particular research being conducted within a university environment, thus naturally we will restrict ourselves to elaborating on one specific social group. The selected social group comprises university students. The change of attitude patterns in group decision making process was being observed, examined and elaborated upon in two groups of students in their second year at the Department of Automatic Control and Information Technology, Faculty of Computing and Electric Engineering, at Cracow University of Technology. The selected subject was Scientific and Technical English, taught within European Union Project.

With reference to Galam's approach [4], we set ourselves a task of borrowing from mathematics those techniques that can be used to build a collective theory of social behavior, within the specific restrictions of psychological facts. The research part of this article contains the building of a model with regard to the real events. Galam states that the socio-psychological part comprises the issues of epistemology, which is closely associated with the concept of the analyzed phenomenon. Our paper in this respect draws upon his approach. In general, we want to combine socio-psychological aspects and mathematical equations, or to use quantitative laws which rule human behavior.

To build a model means to execute some computations in order to gain figures and numbers. Regarding the fact that we are modeling selected part of reality, in the second step our innovative model will be based on the real counterpart of the observable facts. Obviously, dealing with human beings is not so simple. Nevertheless, we would confront our model via investigations on the precisely selected groups of students from Cracow University of Technology. We want to consider small groups, because they tend to be studied in ad-hoc laboratory groups [10]. The purpose is to identify some basic interactions between students representing small groups of agents and to study all the related attributes. As a result, we would be able to exemplify more significant ingredients so as to make the general model more realistic.

Basically, our model is quantitative in the sense that using some algorithms, it yields particular numbers. Moreover, it should provide universal solution to decision making problem. To elaborate on the statement "universal", the goal is to provide a quantitative perception of some human manners, not necessarily with all of the details [4 – p. 38]. As a result, a new framework can be built through the complicated combination of theoretical basis, mathematical algorithms and real life. In general, our model concerns the process of group decision making. It looks for universal features behind all cases of this process, thus it may apply to small as well as to large groups and includes a large spectrum of situations. A quantity is required to measure the ability to change the opinion of each decision maker during group decision making process.

## 2. Consensus reaching process

Decision theory defines decision making problem as the following situation: there are options to choose between and only one has to be chosen in a non-random way. Thus, it is “goal directed behavior in the presence of alternatives” [5].

According to the theoretical basis, we assume that there is a group of individuals (experts, agents) and the finite set of alternatives (options). Experts express their preferences by means of pairwise comparison as to the every pairs of available options. What matters here is that the main goal of group decision making process is to obtain consensus in the sense of the agreement of group members as to the final decision [8]. The decision problem is a multi-stage and very dynamic process which embraces several different levels, i.e. making individual decision of each participant, aggregating all testimonies into one common decision, elaborating on the agreement in the spirit of consensus reaching process. The model of consensus reaching process is manageable only if individuals are able to negotiate and change their preferences. Hence, the main part of this process is discussion, which gives the opportunity to exchange knowledge, clarify point of view, defend own preferences or to become convinced to different opinions.

We assume the topological approach of where agreement is measured on the basis of distance between individuals during every stage of the process. Initially, preferences of group members are very far from each other and the aim is to minimize this distance, and consequently lead the group closer to the consensus. All of the mentioned requirements forced scientists to seek sophisticated tools which support this process and allow to achieve consensus in a more efficient way. Recently developing information technology, named group decision support systems (GDSS), simplifies the process of defining decision problem, leading the discussion, communication between group members, facilitates data analysis etc. The main role of this computer-based system plays moderator which constantly measures distances between individuals, checks whether consensus is reached and, the most relevant task, supports the discussion, i.e. suggests arguments and convinces appropriate decision makers to change their preferences. Doubtless, the moderator affects the general sense of satisfaction within the group and has a direct influence on the quality of final decision. According to the fact that we want to create as human consistent group decision support system as possible and simultaneously, to achieve consensus which would be highly justified, we want to develop and enhance the discussion part and provide the moderator with a specific knowledge about the group members. Briefly speaking, we want to facilitate the work of moderator and, as a result, make the consensus reaching process more effective and efficient.

## 3. Motivation and Principles of Reaching Consensus

An analysis of the change of attitude patters in group decision making process in this paper is strictly linked to the concept of motivation and the practice of motivating members of a group. Regarding the term of “social compensation” [9], individuals increase their efforts on decision making problem to compensate for the meager performance of the other group members. Briefly speaking, group members are mostly committed to achieve the main goal, i.e. consensus. Our task is to define those individuals who are strongly motivated to achieve

success, thus are more likely to change their preferences or have strong influence on others' opinions. Thanks to that we would be able to offer to appropriate (i.e. flexible) decision makers encouragements for conformity and, as a result, to achieve consensus in a more efficient way [10].

Both in theoretical and practical dimensions this analysis is deeply grounded in the scientific conceptualization of consensus. Therefore, at first, a definition of consensus, as well as a proposal of some fundamental, typically used, rules of how to reach consensus, will constitute an indispensable theoretical background for the further developed research. One of the most transparent definitions of consensus embraces creativity as the most crucial aspect: "Consensus is a decision making process that works creatively to include all persons making the decision" [3 – p. 1]. Traditionally, reaching consensus involves putting into practice a number of rules in order to make the process successful.

First of all, in reaching consensus the proposition and presentation of one's opinion should be done as logically and clearly as possible. The teacher/tutor/supervisor/facilitator should be primarily concerned with inspiring reactions of the class members, considering all of them instead of pressing and arguing for one particular solution [3 – p. 4]. Another vital rule is to avoid at all costs an assumption that someone must win and somebody else must lose. In such a situation, usually discussion is led to a standstill. The most important factor in such circumstances would be to search for the most acceptable alternative for all members of the group. Thirdly, it should be stressed that there is a substantial difference between major objections and amendments. The major objection causes a fundamental disagreement, which is an obstacle on the way to consensus. The next important principle to be followed is to suggest that a change of mind for the mere sake of avoiding conflict is suspicious. When agreement comes too easily it should be checked whether everybody accepts the solution for similar or complimentary reasons. Thus, consensus should be achieved on the grounds of logical and objective thinking. Consensus process induces a cooperative dynamic [2]. The fifth indispensable tip is to avoid techniques which artificially decrease conflicts; for instance, bargaining, or voting. Certainly, opinions which differ among group members are a part of a natural process, therefore, every single member of a group should be involved in discussion since a wider range of opinions yields a greater chance to come to the most desirable solutions. Another essential factor on the way to achieve consensus is time. There should be enough time given to all group members to consider and reconsider the final decision and finally accept it [1 – p. 12]. The crowning achievement of consensus is empowering versus overpowering, agreeing and not splitting a group into majority/minority groups or individuals. Last of all, achieving consensus should lead to insight, through participating in the process, one should gain insight in both the minds and the ways of thinking of the group members as well as one's own mind [1 – p. 6].

#### **4. Observations on the basis of selected groups**

This part of the article determines the descriptive capacity of our research. Our initial investigation lied in pure observation of typical behavior of small group of students during the English class. It led us to grasp several distinct attitudes of individuals and, as a result, to determine some generalizations found during group decision making problem. It allowed us to formulate hypotheses, initially non-formalized.

Motivating students to change opinion patterns in two selected groups in the research was conducted according to the above rules, which constitute the governing principles of the consensus process. First of all, it must be accentuated that the choice of particular groups for an analysis was determined by the high level of the group's communicative capabilities. The communicative skills of each of the groups underwent a thorough examination over the period of two semesters. The two groups were characterized by a specific set of personal features of students comprising a particular class: the high level of communicativeness, engagement in class proceedings, general interest in learning, the speedy tempo of moving from one new aspect of the taught material to another. Apart from the set of personal features reflecting the socio-psychological composure of the selected group, the following other elements were taken into account: the group's responsiveness to class tasks as a whole, as well as to home assignments allocated by the supervisor, class discipline, and the multitudinous interpersonal interactions, related either to the merit of the taught material or to the paralinguistic elements within behavioral types in the class environment. Resulting from the above characteristic marks there was created a strong sense of a group image, with precisely delimited psychological and sociological contours, allowing thus to draw conclusions representative of the students' environment.

The first of the two examined groups consisting of twelve (12) students (group A) was characterized by a very lively and enthusiastic attitude to class discussion. Because of better linguistic skills as compared to others, two students from the group emerged as natural leaders, usually taking the role of "experts" or class animators. Differing, however, in their personalities and also an attitude to the teacher/facilitator, they exposed a slightly different way of responding to the entire decision making process. The influence of the two undeniable leaders on the group decision process had both very positive, as well as, at times a negative effect. First of all, a crucial factor was the personality of each of the students. One of them was marked by a very high self-esteem, which caused an authoritative performance of opinions. The positive aspect can be narrowed down, in this case, to exerting a deep influence on other students in the group, whose opinion concerning a particular aspect under discussion was very similar, yet the other students' arguments were not as strong as those presented by the leader. The negative influence, however, was exerted mostly by silencing those arguments which were not wholly wrong, but as a matter of fact, they did not suit fully the context, and as a result they were estimated as wrong.

The other of the two leaders from the first of the analyzed groups, because of a much more outgoing personality, was more likely to be influenced by the voices of the other students in the group, even those which were apparently weaker and usually of less importance in class discussion. It may be said that he represented a model of a natural leader since the process of persuading others into thinking that something was right or wrong took little effort and came as a natural conclusion of the presented arguments. Consequently, the class discussion usually took on a vibrant note. Hardly ever did the discussion come to a standstill, as the arguments were presented by the leader in a very transparent and convincing manner. Evidently, the leader had a very encouraging and activist influence on the members of the group.

As for the other students in group A, there was observed a variety of attitudes and behavioral patterns in the opinion changing process. The teacher/facilitator had to handle a task of constructive maneuvering in a labyrinth of very diversified paths of thinking.

As most of the students from group A showed eagerness to air their views and confront their opinions, more than often a class discussion reminded of a whirlpool with the figure of the facilitator in the very middle of it. Typically, the change in opinion patters was being achieved gradually by continuous checking whether the alteration of the preliminary standpoints was being created on grounds of similar or complimentary reasons. It was a tedious process as it required from the teacher to inspire class participants to view the same problem from a variety of angles, previously unthinkable and seemingly groundless. The major problem was double-fold. There was an easily noticeable tendency of the group to halve itself into two subgroups: easy and fast winners and losers, which demanded an exceptionally speedy tempo while questioning the arguments of the involved parties, as well as balancing of the overhasty and preconceived opinions, giving rise to premature conclusions and final choices. Contrastingly, in some situations many of the group members were prone to accept the opposing arguments too easily for the mere sake of avoiding further argumentation and more developed and demanding mental processes. The loss of motivation observed in our examined group has been already performed by decision making theorists as "social loafing". This phenomenon is assumed to be a punishment for poor commitment of the participating group members and is caused by their low sense of responsibility to the group [9]. However, usually a class discussion in group A caused an insightful change of those elements which were initially of less importance, and subsequently led to a reduction of those ingredients which emerged as mostly impeding the overall agreement.

By comparison, the students in group B (eleven students) constituted a greater challenge for the teacher/facilitator in the change of attitude patterns in group decision making process. There were many sound reasons for it. In the first place, contrastingly to group A, there were no natural leaders, and accordingly influencing the group members in the process of decision making and coming to consensus took a longer period of time, at times it was hampered by a lack of clearly defined opinions, and more than often came to a standstill. Secondly, of no less importance was the fact that a weaker command of English constituted a substantial hindrance in class discussion. By contrast to group A, the class discussion was evidently less vigorous and effective. The third essential factor was a highly time consuming process of differentiation between major objections and less significant opposing arguments. More than often the facilitator was on the verge of deploying, as a last resort, techniques which unfortunately in the long run would decrease conflicting situations in a wholly artificial way, and actually would not bring any clear-cut solutions. There was a temptation of applying the methods of voting and also occasionally bargaining. Not only did the urgent need of using such techniques loomed over the horizon as a blockage of the way to the real change of attitude patterns in group decision making process, but also caused unnecessary upset and limited the smoothness of communication within the class environment, in the most drastic cases it even led to a temporary disorganization of class procedure. An effective group decision making process balances empowering and overpowering, and forefronts techniques which involve the win/win principle. The major difficulty, therefore, in group B was to activate all the group members in class discussion in an equally worthy way in order to make it possible for them to air their views, instead of allowing some of the individuals to press with their arguments. The other vital requirement was to skillfully avoid the presumption that some must be losers and some must be winners.

## 5. The core of our model

We discuss a consensus reaching process in a small group of individuals. What matters here is that the preferences modeling and consensus assessment module are based on fuzzy logic, introduced by Kacprzyk and Zadrożny [7]. Basically, there is a finite set of  $M \geq 2$  individuals  $E = \{e_1, e_2, \dots, e_M\}$  and a finite set of  $N \geq 2$  alternatives,  $S = \{s_1, s_2, \dots, s_N\}$ . Each individual  $e_m \in E$  expresses his/her preferences as to the every particular pairs of options  $(s_i, s_j) \in S \times S$  in the form of individual *fuzzy preference relation*  $R_m$  in  $S \times S$ , and its membership function:  $\mu_{R_m}: S \times S \rightarrow [0, 1]$ . Namely,  $\mu_{R_m}(s_i, s_j) > 0.5$  indicates the preference degree of an alternative  $s_i$  over an alternative  $s_j$ , and  $\mu_{R_m}(s_i, s_j) < 0.5$  denotes, respectively the preference degree of an alternative  $s_j$  over an alternative  $s_i$ . The third possible relation represented by  $\mu_{R_m}(s_i, s_j) = 0.5$  is also acceptable and denotes the indifference between two considering alternatives  $s_i$  and  $s_j$ . Fuzzy logic model used in the consensus measure, makes it softer than its original bipolar approach where 1 denoted total agreement as to the final decision and 0 excluded consensus achievement. We based our research on human-consistent framework proposed by Kacprzyk and Fedrizzi [6], where consensus fits in the range  $[0, 1]$ , thus it is meant as a certain degree of agreement and allows some partial consistency between group members. The measurement of consensus level is a complex counting process, which constitutes i.e. creating the matrix of accordance for individuals and for alternatives, degree of agreement, defining consensus label, computing linguistically quantified prepositions etc. In this paper, we would like to extend the moderator part, i.e. provide more information about group members, facilitate both the leading of the discussion and giving hints to appropriate individuals and, at last, achieve the high quality of the final agreement. Briefly speaking, we focus on the agents' points of view and attempt to reflect on various individual attitudes.

The degree of consensus plays a very important role in guiding a consensus reaching process, because it provides satisfactory agreement among the individuals as to the chosen option. In real life the sense of satisfaction within the group members is very relevant and has indirect influence on the quality of final decision. Our observations proved that some of the observed students were opinionated or dominated by the more active individuals, convinced of their absolute right, while others, did not have enough knowledge about the considered problem and were open to respectfully adopt an opinion of majority. Hence, we want to expand the consensus achieving process on information which individuals are willing to change their opinion and which are persistent in their preferences. It is a well known fact that agents could argue or discuss for a very long time, but they may not decide without making any changes in their own opinions.

Our further research will be based on the social influence model proposed by Zhengzheng Pan [11]. The core is a time-varying influence matrix, where all agents update the influence weights that they place on each other. It reflects changes in attitude that people tend to make during decision making process.

## 6. Influence assignment

The basic framework settings of influence is similar to Pan's description [11]. An influence matrix occurs, which is defined as a  $p \times p$  non-negative matrix  $P^t$ . It indicates the interaction

patterns in time  $t$ , i.e. for every pair of individuals  $(e_m, e_n) \in E \times E$ ,  $p_{mn}^t \in [0, 1]$  denotes the influence weight that agent  $e_m \in E$  exerts on agent's  $e_n \in E$  opinion. Also, the influence matrix is a row stochastic matrix, i.e. the sum of the elements in each row equals 1:

$$\sum_{n=1}^M p_{mn}^t = 1, \quad \text{for all } m = 1, \dots, M \quad (1)$$

and  $p_{mn}^t \geq 0$ , for all  $(e_m, e_n) \in E \times E$  for all  $t$ .

Moreover,  $P^t$  may be asymmetric, so that  $p_{mn}^t \neq p_{nm}^t$  for some  $(e_m, e_n) \in E \times E$ .

At time  $t = 0$  each agent  $e_m \in E$  expresses his/her preferences as to the every particular pairs of options  $(s_i, s_j) \in S \times S$  in the form of individual *fuzzy preference relation*. It is given by function  $R_m^t : S \times S \rightarrow [0, 1]$ , according to the following formula:

$$R_m^t(s_i, s_j) = \{\mu_{R_m}^t(s_i, s_j), (s_i, s_j)\} \quad (2)$$

Moreover, at  $t = 0$  each agent  $e_m \in E$  receives an arbitrary influence allocation, which is a row vector with all elements adding to be 1 as below:

$$\sum_{n=1}^M p_{mn}^t = 1, \quad p_{mn}^t \in [0, 1] \quad \text{for all } (e_m, e_n) \in E \times E \quad (3)$$

## 7. Updating influence weights

For  $t > 0$ , the crucial condition during redistribution of influence is that placing the weights is proportional to the closeness of opinion. The statement of closeness can be simply measured by the idea of distance. On the basis of individual matrixes of preferences the distance between agents  $(e_m, e_n) \in E \times E$  as to the same pairs of options  $(s_i, s_j) \in S \times S$  can be defined as:

$$d_{mn}^t = |\mu_{R_m}^t(s_i, s_j) - \mu_{R_n}^t(s_i, s_j)| \quad (4)$$

and the idea of redistributing influence is based on the weights between agents with regard to the distances:

$$w_{mn}^t = 1 - d_{mn}^t \quad (5)$$

Pan assumed that any individual  $e_m \in E$  does not change the influence he places on himself. He only updates the weights of other agents which are proportional to the closeness of opinions. Hence:

$$p_{mm}^{t+1} = \frac{p_{mm}^t}{p_{mm}^t + \sum_{n \in E_{-m}} w_{mn}^t}, \quad \text{for all } m = 1, \dots, M \quad (6)$$

$$p_{mn}^{t+1} = \frac{w_{mn}^t}{p^t + \sum_{n \in E_{-m}} w_{mn}^t}, \quad \text{for all } m, n = 1, \dots, M \text{ and } m \neq n \quad (7)$$

where  $E_{-m}$  indicates the set of individuals other than  $e_m \in E$ .

Then, for  $t > 0$ , each agent  $e_m \in E$  takes a weighted average of other's current opinion in forming his own for the next period. Thus, the opinions updating rule is defined as:

$$R_m^{t+1} = p_{mn}^{t+1} R_n^t \quad \text{for all } n = 1, \dots, M \quad (8)$$

## 8. Persistent agents

Pan [11] presented in his paper three cases of the minority group of “persistent agents”, who can insist on their initial weights that they assign to others, or insist on their own opinion or both. We want to make further research as for one type of persistent agents, described in the paper as the “type II”, namely individuals who insist on their initial opinions. These individuals would update influence weights, but those weights practically have no impact on their opinions.

Here, in our finite set of  $M$  agents  $E = \{e_1, e_2, \dots, e_M\}$ , a finite subset of  $\sigma \geq 1$  persistent individuals (who do not interact with others) occurs. On the basis of student's group observation, we assume that  $\frac{\sigma}{M} \leq 20\%$ . To unify, the order of agents is that number 1 to  $M - \sigma$  agents are non-persistent and the rest  $\sigma$  are persistent.

We have a set  $C \subset E$ ,  $|C| = \sigma$ . For  $t > 0$ ,  $P^t$  and  $R_m^t$  are updated according to the subsequent rules. For all  $e_m \in E - C$ , the updating process of  $P^t$  is equal to the basic model – equations (6) and (7).

Then, individuals in  $C$  do not update their own opinions. For  $e_m \in C$ , persistent group members insist on their primary opinions:

$$\mu_{R_m}^t = \mu_{R_m}^{t-1} \quad (9)$$

After implementation of those additional assumptions, regarding the research of Kacprzyk and Fedrizzi [6], consensus is meant as a degree of agreement and is measured on several levels during every iteration of the process.

The proposed idea is defined as an agreement of appreciable majority of individuals as regards an appreciable majority of alternatives. Consensus is here expressed by a linguistically quantified statements: “most of the individuals agree in their preferences to almost all of the options”, and the consensus degree (from  $[0, 1]$ ) is calculated as the truth value of this statement. Essentially, the computation of validity can be done by using Zadeh's classic

calculus of linguistically quantified prepositions [12]. To identify a fuzzy majority, *fuzzy linguistic quantifiers* (most, almost all etc.) has been performed. This issue can be also handled via Zadeh's classic calculus of linguistically quantified statements. Regardless of the way of implementation or aggregation particular preferences as to the individual decisions and finally as to the one common group decision, the crucial aspect here is the concept which makes the consensus reaching process softer, more realistic and human-consistent.

## 9. Conclusions

In this paper, we compared two group decision support systems: socio-psychological with the teacher who plays the role of the moderator who manages achieving agreement within the laboratory groups of individuals and computer-based system where some mathematical assumptions make the system more human consistent and realistic. In fact, the former helped us to understand better typical human behavior within a chosen group of students, while the latter allowed us to build more human consistent model of consensus reaching process. Basically, observations on the precisely selected groups shed light on distinctive behaviors which occurred in the small group of agents. In that, we recognized several relevant rules which led the group closer to consensus during decision making process and, simultaneously, we pointed out to the techniques which should be absolutely avoided because they increase conflicts among group members.

Descriptive capacity of our research determined us to formulate conclusions and hypotheses concerning psychological and sociological contours of agent's environment. The vast role of influence was observed, both in positive (deep influence on other student in the group, whose opinion concerning a particular aspect under discussion was very similar) and negative aspects (high self-esteem personality which caused and authoritative performance of opinions). Our observations revealed a significant role of ensuring very good communication among group members and the phenomenon of "lost of motivation," or contrastingly, fast winners who prefer a speedy tempo of the process to the quality of the final decision.

All of these assumptions inspired us to examine thoroughly the literature from the field of mathematical social sciences. Our research led us to a concept of social learning model proposed by Pan [11]. This approach is based on influence factor which also takes into account occurrence of persistent individuals within the group of agents. We adopted accordingly some partial framework of this model to our group decision support system, based on fuzzy logic and the term of soft consensus in the sense of the acceptable agreement of group members as to the final decision.

In this paper there is a framework of a novel, combined approach to the consensus reaching process, which proves that socio-psychological ingredients should constitute an additional field of exploration especially for a researcher from a technical milieu. Its interdisciplinary capacity makes the computer-based support system more human-consistent and enhances specific knowledge of the analyzed process, what is desirable in novel group decision support systems.

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