Social classification structures. Optimal decision making in an organization

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04/29/1998

Abstract

A simple model of organization as a classification cascade is proposed. When a certain business plan or suggestion arrives at the organization, it should classify whether the proposed project is useful or useless. Every individual decision maker has a limited capacity to discern in advance the potential value or harm, the proposed project would bring. Carefully selected structure of decision making can reduce the risk of error even for the case, in which individual decision makers are not adequate to reach correct decisions. An approach to evaluation of decision making structures is proposed. Nearly optimal structures suggested that surpass traditional ones in classification quality.

1 Introduction

All contemporary decision making methods are built after the principle of classification. There is always a set of opinions at the input, but always there is a someone who choose, making the final decision, no matter if that one is a person or a voting majority. The presence of a personal or a collective leader centers the structure, makes it goal-directed and consistent in its actions. So far, the methods of control tend to be either autocratic or democratic, or some mix of the first with the second. In this work, the network model of people interaction is suggested. It is more general relative to widespread hierarchical models.

2 The model of organization as a classification structure

Let us call the persons making classification the agents. The organization is a structure of interacting agents, expected to make decisions about the fitness of the proposals for the organization. An agent has a limited ability to make a distinction between vital and unwholesome proposals. The larger this ability the more qualitative is the agent, as a classification element. This ability can be evaluated, for example, by the probability of his approving the proposal p^+, or the probability of his rejecting the proposal p^-, both depending on the fitness of the proposal for the organization.

The association of agents organized in some way, itself, has the probability of the proposal approval P^+, and the probability of proposal rejection P^-. It is intuitively clear, that the difference D between P^+ of a profitable proposal and P^+ of an unwholesome proposal can be used as a criteria of the good classification.

Suppose we have an organization consisting of n agents. The agents assumed to take decisions indepentently from each other, and they are statistically equivalent,

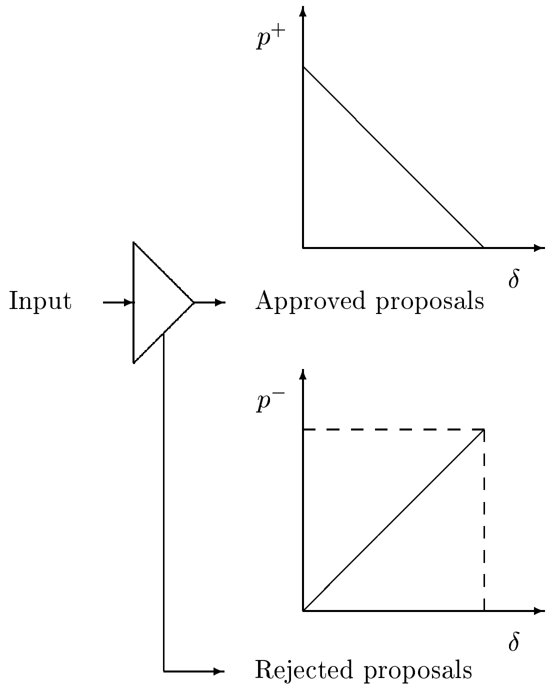

Figure 1: Individual agent and its selective function

i.e. they have the same parameters of classification quality. The main such parameter is selective function of an agent. It is a relationship between the probability φ of approving proposal and the parameter δ of this proposal, that is connected with its future fitness and will become known only after we accept the proposal. In such a way, $p^+ = \varphi$ and $p^- = 1 - \varphi$.

Let us normalize δ in such a way that value of zero corresponds to the maximum fitness with no harm, the value of one corresponds to a totally harmful proposal, and $\delta = 0.5$ corresponds to indifference. Such normalizing reduces the task to the one explored in work [2]. Now, every agent can be represented schematically as a triangle element with one input and two outputs, characterized by the selective function (fig. 1), and the criteria of separation quality depends upon the number of proposals classified wrong. This number can be expressed like

$$\int_{0}^{0.5} p^-(\delta)\, d\delta + \int_{0.5}^{1} p^+(\delta)\, d\delta$$

that correspond to the area between the graph of the selective function and the graph of the unitary step function $1 - u(\delta - 0.5)$. The first item corresponds to rejections of good proposals, the second corresponds to approvals of harmful proposals. In the work [2], the following criterion of classification quality was used

$$\int_{0}^{0.5} \varphi(\delta)\, d\delta - \int_{0.5}^{1} \varphi(\delta)\, d\delta,$$

estimated coarsely by the difference $\varphi(0.25) - \varphi(0.75)$.

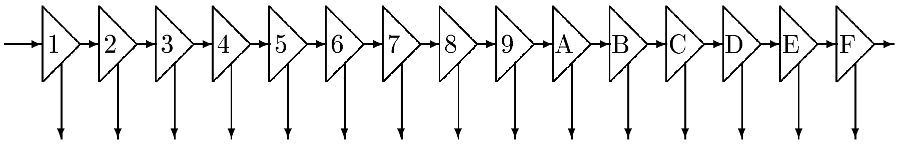

Figure 2: Hierarchical autocratic decision making structure

3 Traditional social classification structures

Let us review some existing structures of decision making and try to determine their classification effectiveness. In particular, hierarchical structure similar to the one shown on fig. 2 is widespread. In this case, a new proposal arrives at the lowest level of the organization, then if approved on every successive upper level, it ascends the hierarchy up to the leader, whose positive decision becomes a decision of the organization. If at some point of its ascending the hierarchy it will be rejected, it leaves the organization, not reaching the leader. The selective function of such a structure is calculated by the rule of multiplication of probabilities, raising each value of agent selective function to the power of n. The organization with such a decision making technology is fairly conservative, so that many decisions, that are good for the organization, become buried at multiple intermediate levels.

Another common way of decision making is a democratic one. It is more difficult to represent the democracy as a technological structure. The decision making by a majority of 15 agents is equivalent to the structure represented at fig. 3. Here, the same agents appear in the different parts of the structure more than once. The selective function of such structure can be calculated by the Bernoully method. Each agent take a positive decision with a probability of p^+, then the probability of n agents take the democratic decision will be

$$P^+ = \sum_{i=\lceil n/2 \rceil}^{n} C_n^i \, (p^+)^i (p^-)^{n-i}$$

when the decision is made by a majority vote

$$P^+ = \sum_{i=\lceil 2/3\, n \rceil}^{n} C_n^i \, (p^+)^i (p^-)^{n-i}$$

when the decision is made by a qualified majority vote (by two thirds).

The selective function graphs for democratic and autocratic structures are shown in fig. 4. By comparing them, it is possible to draw some conclusions about these methods of decision making. First of all, every selective function obtained provides more effective classification, than the one of an individual agent.

It is seen, that democratic method has an advantage in comparison with autocratic method, providing acceptance of a larger quantity of good proposals. The autocratic method is the more conservative the more levels are in its hierarchy. Another advantage of democratic method is its greater reliability when failure of some agents takes place, as a result of corruption, for example. These inferences, made on the basis of graphs in fig. 4, are confirmed by historical data.

Now is the time to compare the results obtained with the results for known and newly found structures of technological classification. The regular structure with recycling [1] is considered nearly optimal for the particle separation. Such structure of 15 agents is shown in fig. 5.

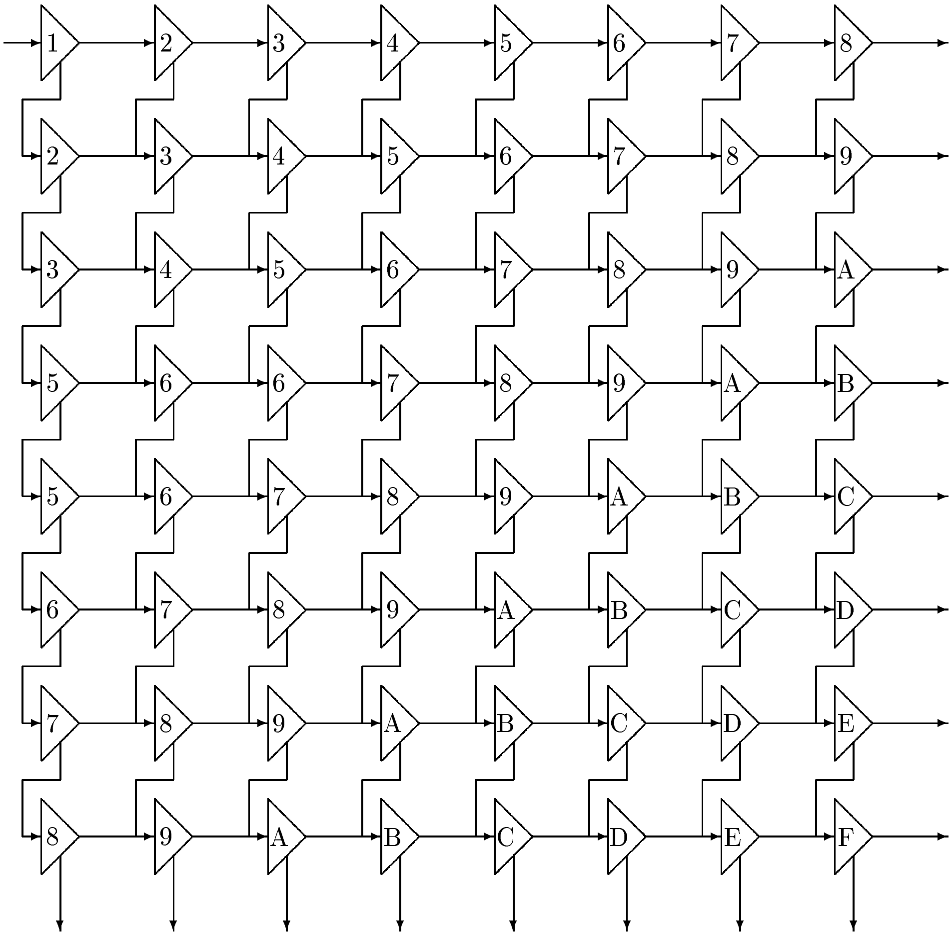

Figure 3: The structure corresponding to a majority vote of 15 persons

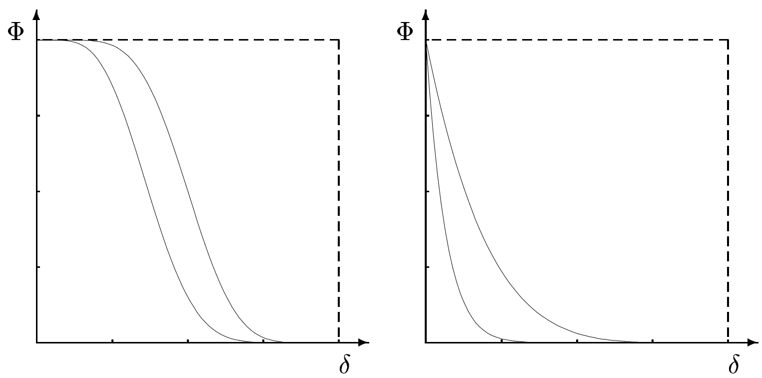

Figure 4: Selective functions of democratic structures controlled by a majority or a qualified majority vote (on the left), and autocratic structures with 15 and 5-level hierarchy (on the right)

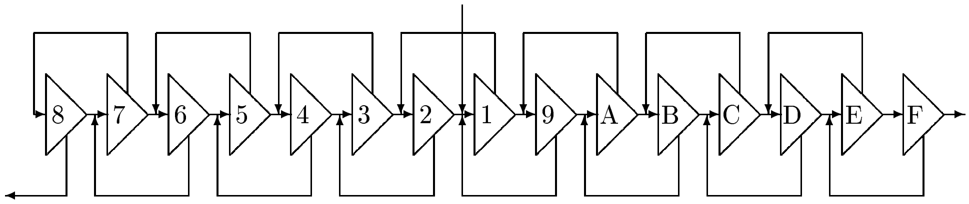

Figure 5: The regular cascade of 15 elements with recycling

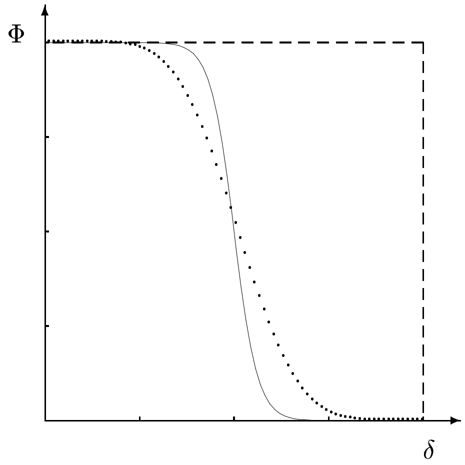

Figure 6: The selective function of the regular cascade with recycling (solid line) compared to the one of the democratic method (dotted line)

In fig. 6, the corresponding selective function is drawn. The dotted line on the figure corresponds to the democratic model with the same number of agents. The essential difference is noticed instantly.

The quantitative evaluation shows that the cumulative error probability in decision making is reduced from 9.21% to 3.71%, when going from the democratic model to the technological one. The cumulative error was estimated as an area bounded by the graph of the corresponding selective function and the graph of unitary step function, corresponding to the ideal classifier. The corresponding parameter for one agent with the linear selective function (fig. 1) is 25%.

The cumulative error probability can be reduced further to 3.06%, if we use irregular structure, generated by genetic synthesis algorithm in work [2].

The stated probabilities of classification error are correct assuming equal distribution of proposals according to fitness parameter δ in the range from 0 to 1. Actually, the distribution often differs from equal one. It can be shown that for a normal distribution with a mean near 0.5, the advantage of technological cascades with recycling is increased in several times.

4 The practical value of the results

It is likely, there is no revelation now, that the structures of decision making used by people without major changing during a long time are still far from perfect. One can hear that the democracy is not ideal method, but we don't know something better.

I can not say exactly, that the suggested here the technological structures will be essentially better in decision making than those we use now, traditional autocratic and/or democratic social classification structures. However, I have no doubt, that there are the areas in which the new methods will be preferrable.

References

[1] M. D. Barskij. *Fractionating of powder.* Nedra, Moskow, 1980. (in russian).

[2] Alexander Kosorukoff. Genetic synthesis of cascade structures for particle classification. to be published.