

# A novel simulation framework for crowd co-decisions

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## Abstract

**Purpose** – The purpose of this paper is to aim mainly at social public decision-making problems, studies the corresponding relationship between different voting rule combinations and the final results, and discusses the quantitative relationships between group intelligence (final votes) and individual intelligence (everyone) to defend democracy under the circumstance of rapid development of network technology, and crowd intelligence becomes more complicated and universal.

**Design/methodology/approach** – After summarizing the crowd co-decisions of related studies, the standards, frameworks, techniques, methods and tools have been discussed according to the characteristics of large-scale simulations.

**Findings** – The contributions of this paper will be useful for both academics and practitioners for formulating VV&A in large-scale simulations.

**Originality/value** – This paper will help researchers solve the social public decision-making problems in large-scale simulations.

**Keywords** Crowd co-decisions, Domain preference, Simulation framework, Voting mechanism

**Paper type** Research paper

## 1. Introduction

The phenomenon of crowd wisdom can be easily observed in daily lives (Michelucci and Dickinson, 2016). In crowdsourcing, crowdfunding, crowd innovation and dynamic supply chain collaborations, crowd wisdom leads people to accomplish tasks using interaction, competition and cooperation, and present itself in both individual intelligence and group intelligence (Wang *et al.*, 2018).

The phenomenon of crowd intelligence can be observed in our daily lives as the proverb goes “two heads are better than one” and “everybody’s business is nobody’s business” (Danishevskaya *et al.*, 2018). Especially, with the rapid development of the network technology, crowd intelligence becomes more complicated and universal, as human, enterprises, governments, equipment and articles become increasingly intelligent, and these intelligent agents to connect each other to form numerous crowd network systems, such as e-commerce platforms, networked supply chains, Wikipedia and network elections (Bonney *et al.*, 2009).

Crowd co-decisions mainly aim at social public decision-making problems, study the corresponding relationship between different voting rule combinations and the final results



and discuss the quantitative relationship between group intelligence (final votes) and individual intelligence (everyone). It mainly includes member definition, member generation, monitoring and verification, as well as simulation framework construction, decision preference solving and other issues.

## 2. Related work

At present, studies on group decision-making at home and abroad mainly focus on two aspects. One aspect focuses on decision-making behaviors, such as social selection theory (Rebello *et al.*, 2018), utility theory and behavioral decision theory, and the other studies group decision-making methods, including aggregation of preference information of group decision-makers, determination of attributes and weights of decision-makers, group decision-making model and processing of uncertain and incomplete information.

The research idea of this paper is to conduct an in-depth study on the process of voting problem-solving. On this basis, the model construction, representation and storage oriented to voting problem-solving and the model-based voting problem-solving method are given. This research idea involves the solving process, model construction, model representation, model storage and model-based voting problem-solving. The research status of these problems at home and abroad is introduced and analyzed.

### 2.1 Research on voting issues

The voting mechanism is the most basic, universal and important choice mechanism in modern public decision-making (Rebello *et al.*, 2018; LIU *et al.*, 2019). It is widely used to effectively express voters' decisions, including the election of public office at home and abroad, the election of company shareholders and the public opinion selection of relevant survey objects on the internet platform. At the same time, analysis, detection and verification can be carried out through economic or mathematical modeling to better realize the decision. Choosing different voting mechanisms (Ao *et al.*, 2018) for the same decision-making problem may produce greatly different results, but there is no unified standard for the specific classification of voting rules. According to certain rules, this paper divides voting into three categories: positive integral rule voting, step process voting and Condorcet extended rule voting.

### 2.2 Preference questions

Studied the conversion relations of four different forms of preference information and proposed an integrated model based on the optimization of relative entropy. Proposed a two-stage group preference aggregation method based on fuzzy programming and established a weight model to maximize the degree of group preference consistency. Studied the method of using individual decision results to form group consensus preference under the condition of incomplete information and multiple indicators. Established a target programming model for estimating group preference weights based on the additive consistency definition of complementary judgment matrix and proposed a domain-based preference representation method based on the characteristics of crowd decision simulation.

### 2.3 Simulation tool

Considering various simulation systems, the most existing simulation software is not suitable for all kinds of crowd-intelligence network simulation (Shih *et al.*, 2019). AnyLogic cannot separate individuals from classification and process them, and it is difficult to process personalized intelligent data bodies. MASON is relatively weak in maturity, so it is

not convenient to apply. NetLogo has no simulation clock and event mechanism, and it is difficult to adapt to the simulation environment of the crowd intelligence network. Repast modeling is very much like a state machine, which can be used to describe a single intelligent number or an entire collaborative group, but the overall architecture of crowd-intelligence network simulation is a little inadequate (Vratonjic *et al.*, 2018). GAMS is convenient for solving optimization problems, but not convenient for driving the execution of the entire simulation. Matlab is a convenient calculation tool, which is convenient for single point calculation, but as a whole, it cannot be used as the basic architecture of simulation (Almeida *et al.*, 2012).

### 3. Research content of the crowd co-decisions

The focus of crowd co-decisions simulation research is the influence of individual intelligence on group intelligence and the benefit from group intelligence. Different from the traditional group intelligence research, it mainly decomposes the complex problems and obtains an optimal solution. The collective intelligence mainly gathers individual intelligence through some mechanisms and approaches the optimal solution in the crowd co-decisions. Based on the social public decision problem, the crowd decision simulation system studies the corresponding relationship between the combination of different voting rules and the final result, and it explores the corresponding relationship between group intelligence (the final number of votes) and individual intelligence (each person) and thus to find out the voting mechanism that can effectively avoid manipulation and design a more efficient voting process that can avoid manipulation.

Before solving the above problems, it first describes the basic classification system of voting, and because different voting systems may have one person for one vote, or many people for one vote, we divide the crowd co-decisions units into two types – atomic unit and collective unit. The atomic unit corresponds to atomic intelligent agents that can hardly be decomposed, such as humans, goods or enterprises, and the collective unit corresponds to intelligent agent groups formed by the atomic unit, such as virtual enterprises, groups and supply chains.

#### 3.1 Voting rules

There are many voting methods, which are divided into three categories: forward integral rule voting, step process voting, and Condorcet extended rule voting. The specific classification (Rebello *et al.*, 2018) is shown in Table I.

3.1.1 Positive score rule voting. Positive score rule voting means that the voters score each candidate, determine the winner according to the score and vote with a relative majority, divided into the following four categories:

Classification	Name
Positive points rule voting	Majority vote
	Borda rule
	K-yes vote
	Negative vote
Step process voting	Two-round run-off
	Single measure shift voting
Condorcet extension rule	Maximum and minimum system
	Ranked Pairs

**Table I.**  
Voting mechanism statistics

- *Relative majority voting*: Relative majority representation system is also known as the simple majority system. To be elected by the candidate receiving the most votes in the constituency or by the party represented by the candidate, no more than half or a certain proportion is required.
- Borda rule.
- K-yes vote.
- Negative vote.

*3.1.2 Step process voting*. A step process voting is a voting process that goes through several rounds, but in each round, the candidate is eliminated. Specifically divided into the following two categories:

- (1) *A two-round run-off*: The winner is determined by a plurality vote followed by a plurality vote for the top two candidates.
- (2) *Single measure shift voting*: All candidates are ranked on the ballot, with the top candidate receiving one vote, and if the candidate with the most votes exceeds a certain threshold value, such as 50 per cent, the candidate with the most votes wins. Otherwise, the candidate with the least votes is removed from each ballot and the vote is counted again according to the above method until the winner is selected.

*3.1.3 Condorcet extension rule*. Condorcet extended rule voting means that the Condorcet extended rule generally refers to those voting methods that follow the Condorcet rule. Condorcet's criterion is a voting principle proposed by the eighteenth-century French mathematician Condorcet. The principle requires the winner of a vote to be able to win in pairs against all other candidates, known as a Condorcet winner. Specifically divided into the following two categories:

- *Maximum and minimum system*: If no option is defeated, the option defeated by the fewest votes wins.
- *Ranked pairs*: Copeland function, Kemeny function, Young function and Dodgson function.

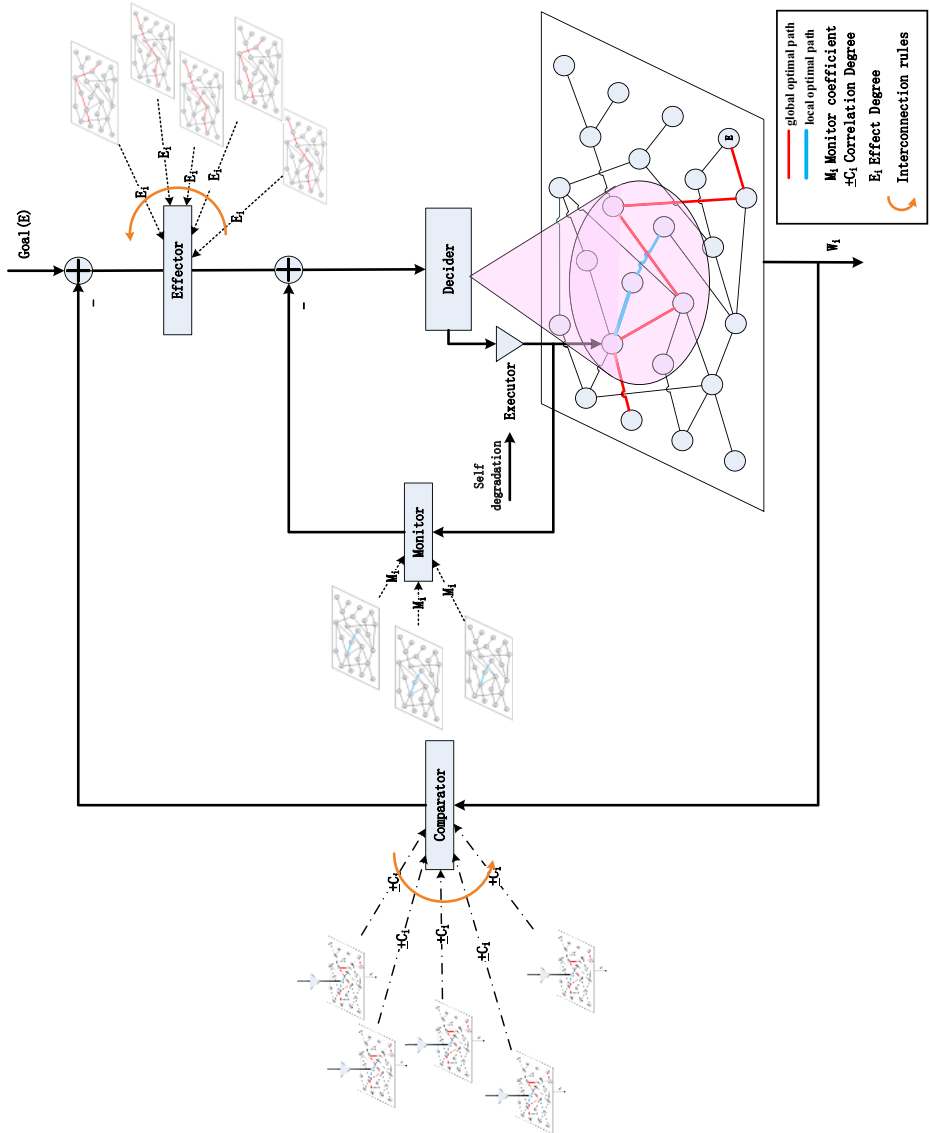
### *3.2 Atomic unit of mind model*

As shown in the [Figure 1](#), an atomic public wisdom unit is composed of six parts: pattern, affecter, comparator, decider, monitor and executor. Its input is the goal or commitment, and its output is the result of behavior (the ratio of benefit to effort), and the specific meaning is shown in [Table II](#).

### *3.3 Collective unit of mind model*

As shown in [Figure 2](#) and [Table III](#), a collection model also has parts of pattern, affecter, comparator, decider, monitor and executor as the atomic model, the input is also given target or commitment, the output is also the result of the behavior (the ratio of benefits and pay). What is more, integrator assembles all related intelligence units to form a gathered decision corresponding to decomposition pattern.

In the crowd co-decision simulation, the influence of different resolvers and aggregators on the crowd decision results are mainly discussed, and the model of other parts may be relatively simple.



**Figure 1.**  
Atomic unit of mind  
model

3.3.1 *Decompositor/integrator*. The decompositor has the ability to decompose the original goal/commitment, and the selector selects the lower level of crowd intelligence units based on the result of the decomposition, partly reflecting the breadth of intelligence. Since voting processes are often needed to be decomposed into several subprocesses, decomposer is needed to separate voters into smaller groups. When voting from target level, decomposer separates voters according to stages and rules and then selectors will integrate results from lower ones to higher (Mao *et al.*, 2018).

In this model, most user inputs are expressed as compound tasks, while set-type decision tasks generally have no clear input and output, which are no different from simple tasks in essence. After task decomposition, complex tasks form simple task sequences. Decision tasks can be represented by the following tuples.

$$(Vid, Vname, Vtype, VI, VO, Pre, Bef)$$

The specific meanings of symbols are shown in the Table IV.

The task decomposition core of this model is to construct a task-spanning tree on the basis of the task tree, which adds dependency mechanism on the task tree.

The root node of the task spanning tree is the set task that needs to be decomposed this time. The leaf node is represented by an ellipse, which represents the atomic task that cannot be further decomposed. The root node and intermediate node are represented by a box, which represents the set task that needs to be further decomposed. The construction process of the task-spanning tree can be regarded as a recursive process. The algorithm is (I think the arrangement is not proper to reflect these lines can be seemed as a whole algorithm):

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Input: vote task T generated by user input in requirement template;
Output: task spanning tree;
Create root node T;
See if T can be divided by the "and" relationship, and if so, updating the before-after dependency set of, creates the child node of T, and a new child node, rotation a), If not, it is atomic, rotation a).
Complete the voting tasks according to the voting rules and record the results.
Break down tasks until there are no complex tasks.
Get task spanning tree and return.
After obtaining the task-spanning tree, the aggregator extracts leaf nodes and dependencies to form task sequences, which are then sent to the decision-making layer.
    
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Noun	Description
Pattern	Pattern is a directed acyclic graph made up of decisions on time series
Affector	The affector is the influence of several proponents' crowd-wisdom units, whose influence intensity is determined by the interconnection rule
Comparator	The comparator connects other crowd-intelligence units related to the crowd-intelligence unit and learns from the results of the behavior of other crowd-intelligence units
Decider	The decider takes resources and capabilities into account
Monitor	The monitor modifies deviations based on specific goals
Executor	The executor performs the selection based on the decisions of the decision-maker and the recommendations of the influencer

**Table II.**  
Meaning of each part  
of the public wisdom  
unit

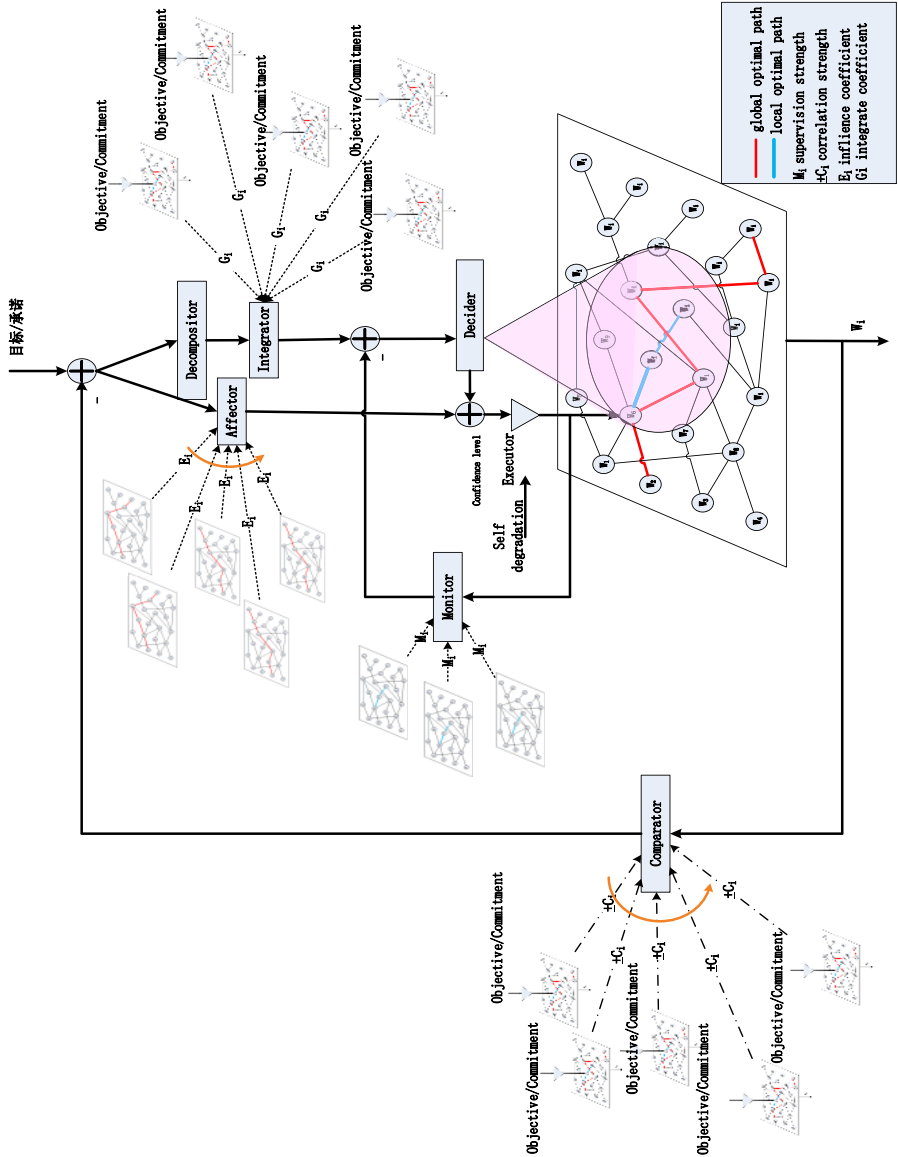


Figure 2.  
Collective unit of  
mind model

#### 4. Representation in the field of preference

Decision preference is the tendency to determine the game. One of the first impressions we get from this definition is that decision preference is first and foremost a term with a human flavor, that is, every decision is made because of people, without which it is difficult to get rid of the suspicion of mechanism. That is to say, decision-making preference – the tendency of decision-making – can reveal the regularity of decision-making process generated by different people’s cognition levels in different social and natural environments for different problems or problems of different people.

For crowd decision simulation, the voting of intelligent number body depends more on the degree of coincidence between the characteristics of candidates and the preferences of intelligent number body. Therefore, crowd decision simulation describes candidate features and preferences in a three-dimensional space, as shown in the [Figure 3](#).

Among them, the *z*-axis represents the field to which information or features belong. Taking the *z*-axis as the normal direction, a field plane is formed. The field plane is represented by polar coordinates, in which there are the preference vector and candidate feature vector of intelligent number body. The direction of preference vector indicates the inclination of intelligent number body in the preference field, and the magnitude represents the intensity of the inclination. The direction of candidate feature vector indicates the preference of the candidate in the preference field, and the magnitude indicates the intensity of the preference.

To better use artificial intelligence, computational theory and other methods to study voting problems, it is necessary to describe voting problems in symbols. [Table V](#) lists some nouns in the description of voting theory.

##### 4.1 Cosine similarity calculation

Set voter  $v_i$  and candidate  $c_j$  in the field of  $n$  preference ratings on vector  $\vec{c}_i$  and vector  $\vec{v}_j$ , respectively, the cosine similarity of voters and candidates are as follows (IEEE *et al.*, 2010):

$$\text{sim}(v_i, c_j) = \cos(\vec{v}_i, \vec{c}_j) = \frac{\vec{v}_i \cdot \vec{c}_j}{\|\vec{v}_i\| \|\vec{c}_j\|}$$

It can be seen from the equation that the value range of cosine similarity is  $[-1,1]$ , and the higher the value is, the greater is the similarity between voters and candidates.

Noun	Description
Decompositor	The decompositor is the decomposition capability for the original goal
Integrator	The integrator integrates the decomposed results of the resolver for the decision-maker to make the next decision

**Table III.**  
Meaning of each part  
of the public wisdom  
unit

Symbols	Instructions
Vid	the ID of the decision task
Vname	Name of the decision task
Vtype VI	voting rule, atomic voting rule is empty particular voting question input set for decision tasks
VO	output set for decision tasks
Pre	the pre-dependent set Vid to perform the decision task
Bef	the post-dependency set of the task

**Table IV.**  
Basic symbols

For example, voter of  $v_1, v_2$  in the preference field of  $d_1, d_2, d_3$ , its score on the matrix of  $v_{ik} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}, i = 1, 2, 3$  and candidate of  $c_1, c_2$  in the preference field of  $d_1, d_2, d_3$ , its score matrix for  $c_{jk} = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \end{pmatrix}, j = 1, 2$ , so voter  $v_i$  and candidate  $c_j$  cosine similarity in the field of preference is as follows:

$$\cos(\vec{v}_i, \vec{c}_j) = \frac{\vec{v}_i \cdot \vec{c}_j}{\|\vec{v}_i\| \|\vec{c}_j\|} = \frac{a_{11}b_{j1} + a_{12}b_{j2} + a_{13}b_{j3}}{\sqrt{a_{i1}^2 + a_{i2}^2 + a_{i3}^2} \sqrt{b_{j1}^2 + b_{j2}^2 + b_{j3}^2}}$$

Assuming  $V = \{v_1, v_2, v_3, \dots, v_n\}$  represents the voter set,  $C = \{c_1, c_2, c_3, \dots, c_m\}$  represents candidate set,  $D = \{d_1, d_2, d_3, \dots, d_u\}$  represents the preference domain set,  $v_i$  represents the  $i$ th voting member,  $c_j$  represents the  $j$ th candidate, and  $d_k$  represents the  $k$ th preference domain. Then, cosine similarity of voter  $v_i$  and candidate  $c_j$  in the  $u$  dimension preference domain:

$$\cos(\theta) = \cos(\vec{v}_i, \vec{c}_j) = \frac{\vec{v}_i \cdot \vec{c}_j}{\|\vec{v}_i\| \|\vec{c}_j\|} = \frac{\sum_{k=1}^u a_{ik} b_{jk}}{\sqrt{\sum_{k=1}^u a_{ik}^2} \sqrt{\sum_{k=1}^u b_{jk}^2}}$$

4.2 Modified cosine similarity

When cosine similarity is used to predict the similarity between candidates and voters, the rating scale of participants (voters and candidates) is not taken into account (Michelucci and Dickinson, 2016). For example, on  $A$  scale of 1-5,  $A$  score above 3 for participant  $A$  was considered favorable, while  $A$  score above 4 for Participant  $B$  was considered favorable,

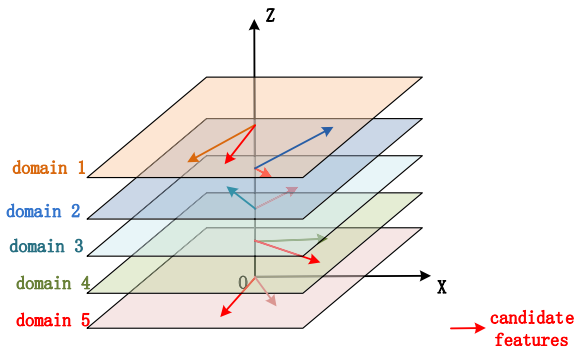


Figure 3. Representation in the field of preference

Table V. Basic nouns and symbols

Nouns	Symbols	Instructions
Voter set	$V = \{v_1, v_2, v_3, \dots, v_n\}$	A limited set of voters
Candidate set	$C = \{c_1, c_2, c_3, \dots, c_m\}$	A limited set of candidates
Preference domain set	$D = \{d_1, d_2, d_3, \dots, d_u\}$	The area of preference involved in a particular voting question

which means that  $B$  was rated more harshly than  $A$ . To solve this problem, the revised cosine similarity is calculated by subtracting the average score of all participants in the current preference field from the score of each term. The equation is as follows:

$$\bar{d}_k = \frac{\sum_{i=1}^n a_{ik} + \sum_{j=1}^m b_{jk}}{n + m}$$

$$\text{sim}(v_i, c_j) = \cos\left(\vec{v}_i, \vec{c}_j\right) = \frac{\sum_{k=1}^u (a_{ik} - \bar{d}_k)(b_{jk} - \bar{d}_k)}{\sqrt{\sum_{k=1}^u (a_{ik} - \bar{d}_k)^2} \sqrt{\sum_{k=1}^u (b_{jk} - \bar{d}_k)^2}}$$

It can be seen from the equation that the modified cosine similarity modifies the mean value of user rating information, eliminating the influence of user rating scale on similarity to some extent. Compared with cosine similarity, it has better effect in some application scenarios.

#### 4.3 Preference domain representation method based on priority graph

Owing to voting on different tasks, different areas may be different, the weight to make the rounds of voting process contain  $T$  a dynamic phase, when the vote at the  $t$  stage, the voting system of state matrix is  $M^t$ ,  $M^t$  vote for the  $t$  round by all voters have given in the process of grading of matrix. Set  $w_k^t = (w_1^t, w_2^t, w_3^t, \dots, w_u^t)$ ,  $T$  is the weight vector of  $u$  fields in stage  $t$ , where  $w_k^t$  represents the weight of the KTH field in the  $t$  stage.

The judgment matrix is established by pairwise comparison of the field indexes according to the priority map method. If the index  $i$  is more important than the index  $k$ , the index  $i$  is 1, the index  $k$  is 0, and the same importance is 0.5. For example, the weight calculation table of priority map in the preference field  $d_1, d_2, d_3$ , as is shown in Table VI.

TTL represents a total optimal ordinal number (the field is the field lines together);  $w_k$  is weight in the field (the total optimal divides optimal ordinal combined ordinal value) (Xu et al., 2019). To determine the validity of the results and accuracy, at the same time, the monitor can use the analytic hierarchy process (AHP) to validate the above weight value.

Let  $w_k^{t+1}$  be the weight re-determined in the  $k$ th field after the  $t$  round of voting.

$$w_k^{t+1} = \beta * w_k^t + (1 - \beta) * \Delta w_k^t$$

$\beta$  is the weight correction coefficient, and it is to set the magnitude of weight correction in the preference field.  $B$  is a constant, and  $\beta \in [0,1]$ . When  $\beta = 1$ , the preference field is no adjustment, and the initial weight of the preference field is maintained. When  $\beta = 0$ , the initial weight of the preference field is not considered, and the weight of the field is determined only according to the field deviation quantity of voting in this stage,  $\Delta w_k^t$  is the weight correction quantity in the voting in  $t$  stage.

Domain	$d_1$	$d_2$	$d_3$	TTL	$w_k$
$d_1$	0.5	1	1	2.5	0.56
$d_2$	0	0.5	1	1.5	0.33
$d_3$	0	0	0.5	0.5	0.11
total				4.5	1

**Table VI.**  
Voting mechanism  
statistics

$$\Delta w_k^t = \begin{cases} \frac{w_{max}^t - w_k^t}{\sum_{k=1}^u w_{max}^t - w_k^t}, & \sum_{k=1}^u w_{max}^t - w_k^t \neq 0 \\ 0, & \sum_{k=1}^u w_{max}^t - w_k^t = 0 \end{cases}$$

$w_{max}^t$  represent the maximum weight in all fields and apparently  $\Delta w_k^t \geq 0$ . Based on the above analysis, the cosine similarity based on priograph method is as follows:

$$\text{sim}(v_i, c_j) = \text{sim}(v_i, c_j)^t = \frac{\sum_{k=1}^u (a_{ik} - \bar{d}_k) (b_{jk} - \bar{d}_k) * w_k^t}{\sqrt{\sum_{k=1}^u (a_{ik} - \bar{d}_k)^2} \sqrt{\sum_{k=1}^u (b_{jk} - \bar{d}_k)^2}}$$

$\text{sim}(v_i, c_j)^t$  represents the similarity between voters and candidates in round  $t$  of voting, and it determines the final decision of voters according to the similarity.

## 5. Implementation

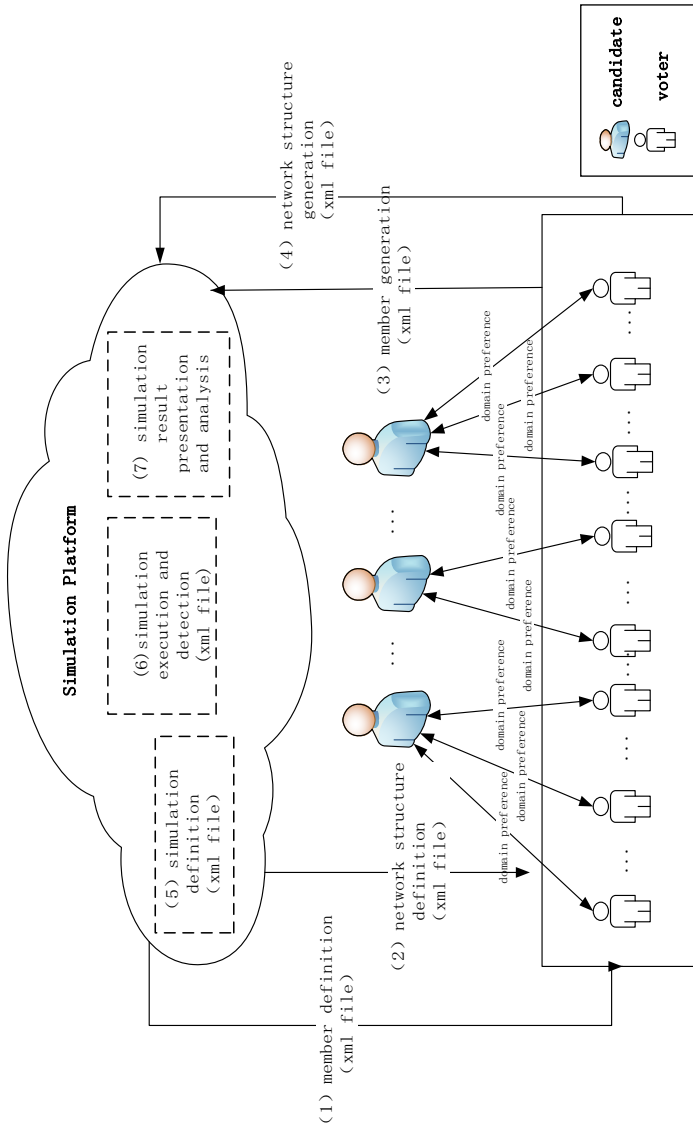
With the rapid development of the network and the prevalence of public intelligence, public decision-making has been transformed into intelligent public decision-making in the network era (Wang *et al.*, 2019). Driven by big data, the new generation of group decision-making mode can achieve the maximization of public decision-making benefits by using the new generation of information technology. The application of computational social choice theory still stays in the research stage of voting theory in the field of computer, and a complete voting system has not been built for large-scale voting simulation. Because there are many uncertainties in the voting process, and there is no simulation system suitable for large-scale voting has been built, this paper builds a hierarchical structure simulation framework, which relies on an xml file to drive the whole simulation process. The levels do not interfere with each other and do not affect each other.

### 5.1 Conceptual model of simulation

The crowd co-decisions simulation system mainly includes seven steps of member definition, network structure definition, member generation, network structure generation, simulation definition, simulation execution and detection, simulation result presentation and analysis, as shown in the Figure 4.

The simulation member definition defines the members of the atomic unit, the collective unit, the advisor and the monitor and the specific definition includes the member's type, attribute, endowment, pattern, executor, decider, decompositor, integrator, comparator and affector. The same time it also needs to define the name, parameters, and models and data sets of the external application and finally generate a member description file in xml form.

- Network structure definition define or generate the overall decomposition/aggregation structure, advisor connection structure and monitor connection structure and write it to the simulation description file in xml form.
- The network structure generation defines the comparator connection relationship and intensity distribution of each member, the affector connection relationship and intensity distribution, the integrator connection relationship and the intensity distribution and writes the information into the xml file.



**Figure 4.**  
The conceptual of  
Crowded Co-decisions

- Member generation defines the number and distribution of different types of members, the distribution of attributes and the distribution of preferences, and then generates the members and writes them into the xml file.
- Simulation definition define the target and direction of simulation optimization, the termination condition of the simulation, the number and position distribution of members, the promotion and synchronization, the voting mechanism, the number of voting rounds, the voting algebra, the monitored parameters and the number of displays. The content ultimately produces a simulation description file in xml form.
- Simulation execution and detection mainly organize and monitor the simulation operation according to the simulation task by obtaining the simulation requirements and corresponding parameters through the simulation description file, and control the execution of the simulation. In the process of simulation execution, each simulation member's state is written to an xml file.

The specific simulation process is shown in [Figure 5](#).

- The simulation result presentation and analysis set the observation parameters and presentation forms according to the member state data in the simulation execution process, and then the simulation results are displayed and analyzed.

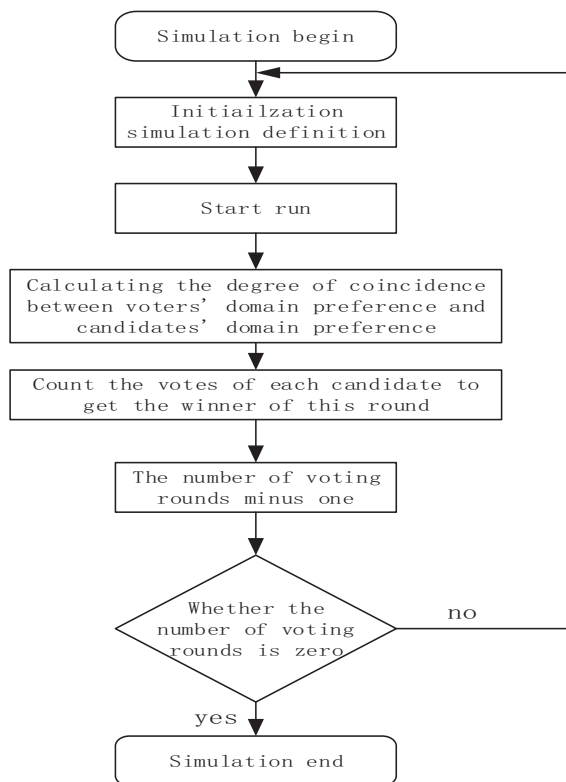
## 6. Conclusion

First, this paper introduces the background and significance of crowd intelligence decision simulation system and introduces the research contents and main innovations of crowd intelligence decision simulation system ([Wang et al., 2018](#)). Secondly, it introduces the relevant theoretical knowledge of crowd decision simulation and the current situation of dynamic group decision-making methods, and then introduces the main content of this paper:

- Because there is no systematic paper summary and analysis of the development of simulation software, this paper looks up various relevant literature and websites, understands and analyzes the existing software and summarizes the widely used simulation software at home and abroad.
- The crowd decision simulation system mainly focuses on social public decision-making, studies the corresponding relationship between different voting rule combinations and final results and discusses the quantitative relationship between group intelligence and individual intelligence. In view of the above problems, the social choice theory and voting problem are summarized, and the preference domain representation method based on priority graph method is proposed.

Although the implementation of crowd decision simulation system in this paper can realize the simulation of the voting mechanism at the present stage, the following contents need to be improved:

- The design of the voting mechanism in the crowd decision simulation system should be updated in real time according to social needs and the appearance of the voting mechanism.
- The crowd decision simulation system is only realized on a single machine, and multiple sets of collaborative operation have not been realized yet. It is not perfect in dealing with large-scale simulation, and multiple sets of collaborative work will be realized in the later stage.



**Figure 5.**  
Flow chart of the  
simulation process

- Crowd decision simulation is a part of crowd-intelligence network simulation. Owing to the overall progress, it cannot be integrated with crowd-intelligence network platform at present. Later, crowd-decision simulation will be integrated with crowd-intelligence network simulation platform.

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