A Quantitative Analysis of Decision Process in Social Groups Using Human Trajectories*

(Extended Abstract)

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ABSTRACT

A group's collective action is an outcome of the group's decision-making process, which may be reached by either averaging of the individual preferences or following the choices of certain members in the group. Our problem here is to decide which decision process the group has adopted given the data of the collective actions. We propose a generic statistical framework to infer the group's decision process from the spatio-temporal data of group trajectories, where each "trajectory" is a sequence of group actions. This is achieved by systematically comparing each agent type's influence on the group actions based on an array of spatio-temporal criteria. Results of those comparisons are then aggregated into a score to make inference about the group's decision process.

Categories and Subject Descriptors

A [**Innovative Applications**]: Public Policy and Economics

General Terms

Group decision-making

Keywords

Group behaviors; trajectories; decision analysis.

1. INTRODUCTION

When a decision is reached by a group of agents, they have to collectively make a choice from a set of alternatives wherein not all members may be in complete accord with. We call a *joint* decision by a group a "consensus" because every group member has to compromise to agree to it. A group is called *cohesive* if consensus decisions are consistently reached. A social group (i.e., a group in which individuals have established social ties) is *heterogeneous* if it is composed of members having *differing* interests – that can be elicited. In this paper, we only consider heterogeneous and cohesive social groups.

There are two broad processes under which a group decision is made: (1) decision may be reached in a "democratic" manner, where the average behavior of the majority of the member agents is adopted; or (2) it may be made in a more "despotic" manner [5, 3]. While the former is often obtained through some voting mechanism, the latter is typically the result of delegating the decision-making power to an elite minority [3], which is referred to as the *dominant* type. If there exists no dominant type, then the group has a *balanced power structure* [2, 4]. Whereas, if the group admits a dominant type, it has a *dyadic dominance structure* (or just *dominance structure*). In this case, group members can be divided into the *dominant* and the *subordinate* type [1, 3].

2. PROBLEM STATEMENT

The outcomes of group decisions may reflect its dominance structure. We assume that members in a heterogeneous group can be divided into two agent types of differing interests: A and B. We call such a group a *bipartite* group. We suppose that the group has size at least two and it has at least one member of each type. Suppose also that the differences between A and B can be characterized or elicited by their respective *independent* set of preferences towards a finite and temporally ordered sequence of "decision points". We call such a sequence a *trajectory*.

We denote the bipartite group made up of A and B as C. Let s be a finite sequence of decisions, then $i \in s$ is a particular decision made. Let S be a finite set of abstract "locations" and let the group's decision problem be choosing a subset $s \subseteq S$ to visit sequentially over a finite period T such that s cannot contain repeated locations. Suppose that A and B have *revealed comparative differences* in their preferences (that we have elicited). Given the *independent* trajectories of A, B, and C (as the group's), we wish to infer the dominance structure between A and B in C.

3. THE SOLUTION FRAMEWORK: GDAT

We propose a generic statistical framework called GDAT (**G**roup **D**ominance **A**nalysis via **T**rajectories) to address the problem. Figure 1 illustrates the high-level schematic of the framework. It shows that GDAT consists of three main sequential *components* labeled by the numbers 1–3 and each is bounded by a dashed-line rectangle. The solid boxes

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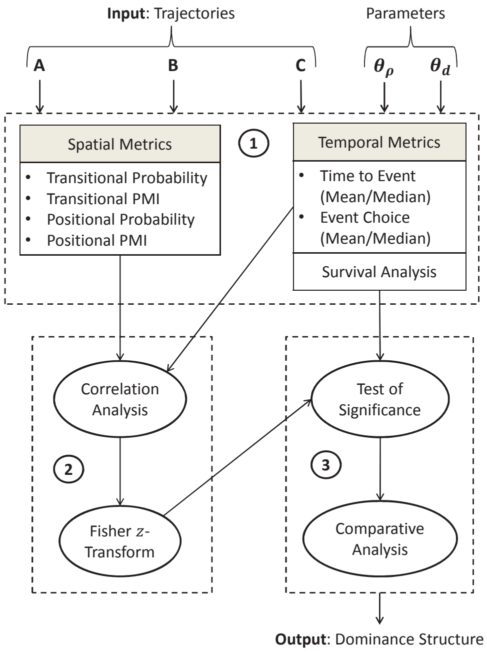

Figure 1: The solution framework (GDAT)

denote the metric sub-components of component #1 and the ovals denote the procedures performed upon them.

The first component involves calculating certain statistical metrics from the given trajectories, which are categorized into two sub-components: the spatial and the temporal metrics that capture the spatio-temporal aspects of decision-making. The exact metrics, how many of them, and how to categorize them are not essential here. Instead, they should depend on the given data and what metrics can be effectively derived. The flexibility of our framework is that one could add or remove any metric components to adapt to their problem as necessarily. Table 1 summarizes the proposed spatio-temporal metrics in this paper.

Table 1: Summary of the spatio-temporal metrics

	Metric	Notation
Spatial	Transitional Probability	$\Pr(i \to j \mid i)$
	Transitional PMI	$\mathrm{PMI}(i \to j)$
	Positional Probability	$\Pr(i, k)$
	Positional PMI	$\mathrm{PMI}(i; k)$
Temporal	Mean Time to Event	$\bar{\tau}_i$
	Median Time to Event	$\tilde{\tau}_i$
	Mean (Event) Choice	$\bar{\gamma}_i$
	Median (Event) Choice	$\tilde{\gamma}_i$
	Logrank Test's p-value	p_S

The second component involves two procedures: Correlation analysis and Fisher z-transform upon the metrics obtained from the first. This step tries to elicit the differences in influence between the two types. Figure 1 also shows that all the metrics from the first component, except for "survival analysis", have to go through this. On the other hand, survival analysis, whose output is the p-value of the logrank test, goes directly to the final (third) component.

The third component tests the statistical significance of the differences between each agent type's influence on the joint decisions (i.e., C's trajectories). It then aggregates all the test results into a final score to infer about the group's dominance structure using a comparative procedure.

Finally, GDAT takes in the *independent* trajectories of A and B together with the group's (i.e., C's) trajectories as the input. The input parameters are: θ_ρ (the threshold of correlation) and θ_d (the threshold of determination). GDAT outputs the inferred dominance structure of C (i.e., whether it has a dominant type, and which one of the two, if any).

4. CASE STUDY

We have collected a large dataset of trajectories of agent types A (Adult), B (Child), and C (Family) in the context of visitors traveling in a theme park. The trajectory s is a sequence of visits to a finite set of attractions S. Each visit $v = (a, t) \in s$ is a tuple where $a \in S$ is the attraction visited and t is the timestamp of the visit. Table 2 shows the correlation analysis results for these trajectories. It shows that, for all the metrics where A and B have revealed comparative differences (i.e., $\rho(A, B) < \theta_\rho = 0.90$), A exerts more influence on C than B (i.e., $\rho(A, C) > \rho(B, C)$). The last row of the table gives the p-value of the logrank test.

Table 2: Results of the correlation analysis

	$\rho(B, C)$	$\rho(A, C)$	$\rho(A, B)$
$\Pr(i \to j \mid i)$	0.699	0.899	0.728
$\mathrm{PMI}(i \to j)$	0.319	0.547	0.412
$\Pr(i, k)$	0.882	0.948	0.893
$\mathrm{PMI}(i; k)$	0.793	0.864	0.753
$\bar{\tau}_i$	0.656	0.880	0.838
$\tilde{\tau}_i$	0.445	0.895	0.657
$\bar{\gamma}_i$	0.887	0.900	0.914
$\tilde{\gamma}_i$	0.620	0.903	0.763
p_S	0.003	0.356	< 0.001

Our analysis indicates that Adult is the dominant type (i.e., decision-maker) in the Family groups consisting of Adult and Child agent types. This makes common sense given that one has prior knowledge of what A, B, and C actually are. That is, in most practical situations, adults are more experienced and capable at planning and carrying out activities and than children. On the other hand, this also lends us a favorable ground truth in validating GDAT, i.e., it has inferred something that aligns well with real life.

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