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Opinion convergence in location: A spatial version of the Delphi method

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ABSTRACT

This paper proposes a modified version of the Delphi method, starting from the assumption that in many situations the convergence of opinions can be considered in a spatial context. The Spatial Delphi we suggest is based, like the classical Delphi, on the judgments of experts, and it is useful in the consultations for decision and/or forecast purposes, provided that they concern matters of spatial location. The basis for the questionnaire is a map, on which each expert provides, as answer(s), one or more opinion-points, i.e., locations that, according to their opinion, are best for a specific purpose. We propose a method for narrowing the area of convergence along a multi-step procedure so that the final result of the consultation is a small portion of the initial territory with respect to the initial area considered. Besides a simulation study, we report also a prototype application with a panel of twelve experts.

1. Introduction[1]

Consultation is a form of passive participation[2] that collects the opinions of a sample of people, either individually or in a panel. The panel implies several interviews of the same people at different times (either synchronous or asynchronous). Delphi enables horizontal communication processes among people within a panel, giving them the opportunity to obtain a convergence of opinions. By the expression "convergence of opinions" we mean a structured process in which individual thoughts on issues under discussion lead to relatively shared conclusions. In convergence of opinions, eliminating the errors resulting from direct communication is necessary (e.g., errors resulting from leadership). Delphi narrows the range of assessment uncertainty without producing errors that result from face-to-face interactions, thus reinforcing the collective intelligence generated by the panel's opinions. Ultimately, the intuitive reflections of the panel experts generate the synergistic thinking, which is the basis for collective intelligence. The Rand Corporation [3] developed Delphi with the aim of achieving assessment convergence across members of a panel addressing the same question. The dissemination of the Delphi method has been so rapid that in the second half of the 1970s, Brockhaus and Mickelsen [4] analyzed almost 600 applications[3]; its most recent evolution is now online and in real-time ("Real-Time Delphi" [5]).

"Spatial Delphi" is a method inspired by the logic of the classical Delphi, from which it also inherits its application purposes: consultation for decisions or forecasts. But in Spatial Delphi, we deal with problems of spatial location. We use the problem of the optimal location of a warehouse as an example. To solve this problem, we can calculate the minimum distance between users, but how can we be sure this is the best choice? To be sure, one should adopt a participatory approach that ensures a convergence of opinions regarding the warehouse location. Similarly, we can evaluate the probability that a catastrophe will occur at a given location using objective methods, but the initial indication of danger comes from the people who live there; in this case, their assessment would be

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[2] Considering the whole decision-making process, the participation may be: a) *technical*, when the opinions are given by experts; b) *mediated*, when they are provided by the representatives of the community; and c) *direct*, when they are given by citizens [1]. With regard to the methods for participation, see Glenn J. C. [2].

[3] In particular, in 598 studies, 26% were applications in the physical or engineering field, 23% in the market, economics and social sciences, 19% in education and public administration, and 9% in biological sciences and medicine.

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helpful. In the literature, subjective data are weaker than objective data, and this fact brings out Delphi's main virtue. Putting aside the scientific inferiority of subjective data, the question becomes: how can subjective evaluations be strengthened? As in the classical Delphi, the subjective evaluations of several people should be converged. To achieve this purpose, one should structure the following:

1. Collection of judgments in an iterative framework (i.e., controlled feedback) so that participants can review their assessments several times after comparing them with the responses of the group;
2. Contacts (e.g., through anonymity);
3. Opinion convergence (e.g., provide ranges identified through statistical parameters).

For the application of Delphi in the field of forecasts and spatial decisions, we propose a procedure that inserts two innovations in the third point, i.e., in structuring the convergence of opinions.

a) In the classical Delphi, the convergence is governed by the interquartile range, which contains 50% of the respondents. In our Spatial Delphi, we keep these guidelines, but rather than an interval containing 50% of opinions, we use an area. According to the requirements of the problem, other percentages of opinions may be adopted to construct the convergence area, also considering the time needed for convergence. We face now two problems: the shape of the area and its location.
   First, the evaluations of the panel are represented as a cloud of points on the study area, where each point represents the evaluation of one expert with respect to the localization problem. These points are *opinion-points*. Regarding the shape of the convergence area, a broken closed line connecting the external opinion-points of the cloud and containing 50% of the opinion-points is less wide than a circle but would leave less space for the assessments of a subsequent iteration. Therefore, in this first approach of the Spatial Delphi, we use the circle to leave room for later iterations. Furthermore, in a spatial domain—without additional information—we cannot have a favorite direction, so the circle is the only anisotropic 2-D shape usable.
   Second, we decided to center the circle on one of the opinion-points because any other central point (e.g., the geographic mean or median center) would not guarantee an evaluation for that location. In other words, we want to avoid a correspondence between the center of the convergence circle and a location not expressed by the panelists.
b) Within the classical Delphi, each expert provides one evaluation for each step, whereas in the Spatial Delphi, experts can give multiple opinion-points according to the number of rounds. For example, in a three-round procedure, each panelist identifies three points in the first round, two points in the second round and one point in the final round. This way, we collect a greater quantity of points and the respondents are guided toward more accurate considerations. We think that having fewer opinions to express will allow experts to be more creative and bold at the beginning of the procedure and be increasingly careful and thoughtful as the procedure continues.
   These two innovations are implemented in the stated order and in two different situations: (a) with a simulation study, we present the area of opinion convergence with only one opinion-point for each expert and iteration (Section 4) and (b) in a prototype study with 12 experts, we also tested the approach with decreasing opinion-points (Section 5).

2. Spatial point of view[4]

The human brain is habituated to think spatially. Many mental operations and decisions involve spatial reasoning. Going to work, driving a car, searching for an address and finding a hotel on the Internet are examples of operations that involve decisions made on a map, which can be both real (e.g., paper or digital) or mental (e.g., when going to work, our brains follow a cognitive map of the route). Therefore, the convergence of opinions in a panel of experts is in accordance with this logic, considering that "space" is an indispensable part of many shared choices. Dragicevic and Balram [6] were the first to define the concept of "Collaborative Spatial Delphi" (CSD). That paper used the Geographic Information Systems technology (GIS) to manage digital maps with other exploratory spatial analysis that—in a planning context—serves to support the convergence of opinions obtained with the Delphi method. Basically, CSD involves tools that support group decision-making such as sketches created directly on a digital map, documents, and the construction of statistical indicators [7]. During consultation, experts use a digital map to draw polygons and write comments directly "on the territory""; convergence of opinions is reached using the classical Delphi technique. The classical Delphi is supported by Web GIS to create a complex tool for the convergence of opinions in a spatial decision-making framework. In the words of Dragicevic and Balram [6], "Cognitive mapping, the Delphi procedure, and consensus approaches are the main components integrated to structure a shared virtual space for problem-solving and planning." In contrast, our approach starts from a different point of view. We propose narrowing the opinions of the experts in space (i.e., find a location in the area of interest—or at least a narrow region—on which there is convergence of panelists' evaluations). Therefore, we use the expression "Spatial Delphi" in a completely different way compared to the existing literature.

The problem of finding an optimal site can be analyzed from three points of view:

A. The present: the problem of choosing an optimal site (i.e., Best Location Site) to place goods or services (public or private) or to act for a specific intervention. An important example would be choosing the best place to land a spacecraft on Mars. There are various techniques to resolve this problem, but all start with quantitative approaches in the sense that the best place for the localization is selected through maximizing an objective function using variables inputted into a model. Other possible applications concern the field of land use management (forestry: the area where it is better to deforest; agriculture: the best field for crops; wetlands: where it is more appropriate to drain) or nuclear waste (what is the best place for storage).

[4] S. Di Zio.