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Review Article

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Issues and Challenges of Incorporating Time and Temporality in Human Geographical Analysis

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Human geography is regarded as a discipline related to people, environment and space. In fact, it has a long tradition to take time factors into consideration [1]. However, most of early studies focused on conceptual, experimental or sectional analysis [2]. With the abundance of time-stamped data, the granularity of time recording, and the improvement of computing technology in recent decades, it became possible to incorporate time and temporality in a more accurate, multi-scale and dynamic way. In addition, similar analyses with tempo-spatial characteristics are widely adopted in adjacent fields, such as human mobility [3], urban planning [4], history [5], social physics [6], epidemiology [7], etc. We reviewed relevant researches from multi-disciplines and summarized key issues and challenges in three aspects: data acquisition and processing, analytic framework, interpreting and applying results.

Data Acquisition and Processing

There are a series of issues when we acquire and process temporal data, for example, how to deal with multi-source/multi-format data, how to set data sampling with appropriate intervals, how to integrate, manage and represent temporal data with other attributes, and how to desensitize data in accordance with privacy policies. Moreover, the volume of data and the level of difficulties will grow exponentially when more precise data are captured and processed. In addition, we found that most of researches in the fields were project-based and relied highly on data from third parties-either from public agencies or from private sectors. With that being said, each dataset was isolated, difficult to be migrated and shared, and lack of continuous observation.

Analytic Framework

At individual level, each research was based on solid analytic modeling and scientific reasoning. But if we look all relevant researches as a whole, it seems more or less of chaos in tempo-spatial analytics. Different time scales were used for different research purposes, ranging from seconds, minutes, days to years or even longer. Researchers had different angles of view e.g, from analyzing individual's driving behavior in telematics [8], to studying people's job and housing dynamics in planning [9], to exploring whether human's traveling and commuting patterns follow similar law of nature in social-physics [6]. Different tempo-spatial models were applied in geography, as well as numerous specific models from other fields [10]. Different software and tools were used, from commercial releases, to open-source tools, and to self-developed prototypes. All these lead to an inevitable phenomenon - 'research silos', i.e., research methods varied from field to field, few of analytics could be reused and modeling details were hard to be communicated from cross-fields. But our world immersed in time and space is a comprehensive and inter-connected system, no matter how researchers view, scale or model it. So it might be the right stage that we should build a holistic framework together to better conceptualize and analyze the real world with time-space. Some key issues on this framework could be discussed, defined or standardized, including but not limit to how to align the view of time-space from different disciplines, how to set the references on time measurement for different purposes, how to link, upscale or downscale the objects with different time resolutions, how to specify the input, output and interface of the analytic models from different fields.

Interpreting and Applying Results

It is obvious that cross-field collaboration is critical in understanding time-space research. However, it is challenging to get researchers, data scientists, and industrial experts well involved and aligned. One of the best practices

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so far we have seen is a case within the telematics-related field. Location data of vehicles are captured per second by engineers. Data scientists detect and analyze driving behaviors, such as accelerating, braking, steering speed, from raw location data. Actuaries integrate driving behavior factors with other attributes to price risks for car insurance. Psychologists identify and treat road rage by combining driving behavior data with more environmental indicators. Designers for autonomous driving improve their products by recognizing the difference of the driving patterns between machine and human. These researches and applications are closely entwined. From this case, we could imagine that there is foreseeable room for improvement by encouraging further cross-field collaboration.

We summarized the aforementioned issues and challenges from a research management perspective rather than a purely technical perspective. There is no doubt that, to solve these issues requires broad and continuous efforts from all relevant fields. To begin with, we suggest that it is important to build the collaborative framework with four pillars - online communities, data sharing platforms, open-source tools, and cloud computing power.

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