III: Small: Investigating Spatial Big Data for Next Generation Routing Services

Institution: University of Minnesota-Twin Cities

NSF Program: Information Integration and Informatics

Principal Investigator: Shekhar, Shashi

Rating: Excellent

Review:

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

This proposal proposes new methods for route service for Spatial Big Data (SBD).

As stated in the proposal, effective route service will reduce fuel consumptions and greenhouse emissions. It is an important research issue. With the growth of GPS and mobile device, more and more data are available for researchers to devise new methods to provide better route service. This proposal is proposing to provide a new solution this problem.

The proposal identifies three major problems, namely, change of reference frame, partial nature and ambiguity of traditional routing query, and the need for diverse solution methods. In Section 3, the proposal explains what are the difficulties, what are the proposed solutions to these problems.

The route service problem is not new, but the proposed solutions (Lagrangian Xgraph, all start-time Lagrangian shortest paths) shed new light on this traditional yet important problem.

The proposed project management and evaluation plan described in Section 6 is solid.

The PI has extensive research experience in spatial database management. The PI and his team are qualified to carry out the proposed research. The team has access to data they need to test the proposed solutions. The PI's home institution has adequate resource to support the proposed research.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

If successful, the proposed research will provide an infrastructure for the research community as well as benefiting general public.

The education component of the project includes curriculum enrichment, involving students from under-represented groups, and incorporating K-12 education.
Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable.

Summary Statement

This proposal is very well written. The proposal clearly states the problems need to be solved, identifies the challenges, and describes the proposed solutions.

The proposed research not only provides an infrastructure for researchers in database and civil engineering and urban planning communities but also has a significant impact on economy and environment.
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Review:
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Strengths

+ The proposal is important in advancing the knowledge of routing services based on spatial big data, which makes it possible to generate routes for different starting times, with a specific preference, by utilizing algorithms working with different spatial data. This is a great improvement over traditional router service research.

+ The proposal is conceived based on a clear understanding the challenges posed by the new spatial big data. The proposed activity is well organized into three major components, from new network representation framework, route query, and algorithm ensemble architecture, following a sound logic.

+ Multiple creative concepts have been proposed, such as the award winning Lagrangian Xgraphs to represent node, edge, turns; critical time-point base divide and conquer to address non-FIFO and non-stationarity challenge; and K-Median for Route-Collection based on route similarity, which are ground breaking for the computer sciences and geospatial sciences fields.

+ The PI and his team are reputable experts in transportation modeling, spatial database and spatial data mining, evidenced by multiple NSF grants that generated a multitude of research publications and Ph.D. student dissertations.

+ The PI has access to a wide variety of resources to support his research, including collaborators from Center of Transportation at the same university, and commitments from ORNL, Oracle spatial, Microsoft, ESRI, NAVTEQ and other strong partners in providing data and expertise.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Strengths:

+ The project can potential reduce energy consumption and greenhouse emission through it eco-routing services.
+ The publication of the research outcomes in peer reviewed journals and conference will directly benefit the computer sciences as well as geospatial sciences.

+ The research will enhance the graduate level spatial Database Research curriculum and undergraduate level algorithms and data base curriculum by introducing spatial big data research components.

+ The car monitoring hardware and acquired in this project and the valuable datasets thus collected, and the open source software developed to analyze the data will also enhance the PI and other researchers' ability to tackle other energy consumption based research in the future.

Weaknesses

- More active efforts to disseminate research results is expected to reach out a much wider audience such as transportation planners who can greatly benefit from the research.

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

Summary Statement

This is an excellent proposal with well-organized research and evaluation plan. The concepts proposed concerning spatial big data based routing service are creative and transformative for the computer and geospatial sciences. The results from the research have the potential to benefit not only the relevant research fields academically but also society in reducing global environmental problem.
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Rating: Excellent, Very Good

Review:
In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

A well-written project plan lays out a set of distinct research questions centered on next-generation vehicle routing services in the context of spatial big data. The focus is on the computational support needed for individualized routing that minimizes time for travel and also weighs routing according to eco-fuel consumption. The research moves previous work on time aggregated graphs developed for spatial routing problems into a big data setting where a very large number of (temporally detailed) routes must be determined and summarized using Lagrangian Xgraphs. The route-from-gps query research is a new direction that while challenging will be of quite some interest for researchers working on routing services as will the on-the-fly distinction of critical time points for generating shortest paths and other topics relating to fuel consumption travel analysis such as patience-payoff. These are all solid research undertakings and I wonder if perhaps the proposed scope is a bit ambitious for the timeframe? To consider eco-fuel consumption methodologies as well as routing and travel time is definitely a lot to get through.

The proposal appears to be mostly written from the perspective that the results will primarily benefit an end user in a vehicle. The discussion refers to some user interface work on cell phones describing route recommendations for individuals. The results could also presumably be used for overall traffic management. Both are possible, and so what are the differences for these two different requirement scenarios?

The data management plan is very strong with good plans for data storage and handling and long-term plan for data curation and preservation with a digital conservancy group at the University of Minnesota.

The PI has a well established track record relating to prior research in spatial databases and spatial routing algorithms and can be expected to complete these research obligations.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Very strong broader impacts as the investigator plans to work with collaborators at Navteq that has a strong interest in travel services and ORNL that is interested in new methods for reducing fuel consumption. Additional collaborators include Microsoft Research, Oracle Spatial, and a transportation...
research center at the University of Minnesota. A new emphasis on spatial big data and next
generation routing services for undergraduate and graduate computer science student is expected to
lead to a new curriculum.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

Summary Statement

A very strong proposal that takes current research on travel routing services and investigates the
computational needs and approaches for routing in new temporally detailed route settings that involve
spatial big data as well as eco-fuel consumption constraints. Clear set of research questions, plans for
evaluation, and expected outcomes. Very strong broader impacts for both transportation services and
education.
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Review:

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

Strength

- Innovative concepts with deep thinking on new application
- Interesting model, the Lagrangian Xgraph, is introduced.
- Excellent past record on innovative research
- Strong past NSF support and high productivities.

Weakness

- This is a high potential and high risk proposal. As the proposer pointed out, there are many challenges and some challenges may make the implementation of the proposed solution to the next generation routing services in practical.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Strength

- If successful, the results from the proposed research will of big impact on routing and environment by recommending eco-friendly routes.
- Algorithm and techniques developed in this project will be made available as open source software.
- Commercial values of the research is reflected by the letters from both Oracle and ESRI

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

Summary Statement

Summary

The team considers the technical issues for supporting next generation routing services and proposed
a new frame of reference for car travelers. The Lagrangian Xgraph concept introduced by the proposer
seems to be innovative and of practical value if it can be successfully developed and implemented. The
proposer discussed many potential challenges for a complete and useful system based on this
concept. For each challenge, at least a potential solution (or potential solution options) is given.