

An approach towards considering users' requirements in transport data visualisation

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1. Introduction

Undoubtedly the integration of Human-Computer Interaction (HCI) tools and methods in the design and development of geospatial technologies is getting increasing attention. Research studies highlight the importance of, amongst others, user involvement in design and usability issues. Recently formed specialist groups (e.g. ICA Commission: on Use and User Issues and on Cognitive Visualisation) review and promote a collaborative scientific understanding and experience in HCI with the aim to improve interaction with geographic visualisations and systems.

Almost 80% of current digital data is geographically referenced (MacEachren et al., 2001) as, "Everything that happens, happens somewhere" (Longley et al., 2005; p.2). This, combined with the cognitive benefits of digital maps (MacEachren, 2005) make geovisualisations popular especially in contexts such as transport, health and crime where complex spatio-temporal datasets are usually involved. In order to cope with data complexity and produce meaningful representations to support knowledge production, geovisualisation research studies focus on technical aspects, such as applying computational techniques for pattern exploration (Rinzivillo et al., 2008) and methods for data abstraction through aggregation or generalization (Zhao et al., 2008).

A more recent focus in geovisualisation is concerned with aspects of interaction, such as usability evaluations, while a growing number of research studies emphasizes User Center Design (UCD) and call for greater attention in the initial design stages such as gathering user requirements (e.g. Dykes et al., 2005; Andrienko et al., 2006; Lloyd et al., 2007). Maguire and Bevan (2002) explain, "It is now widely understood that successful systems and products begin with an understanding of the needs and requirements of the users." (p.133) which is further specified in the ISO 13407 standard (ISO, 1999).

In this paper, we demonstrate a preliminary user requirements study and exhibit how the results influence the design of a visualisation system for traffic congestion (spatio-temporal) data used by Transport for London (TfL) experts. Our preliminary results reveal that user requirements analysis can reveal visualisation aspects that are usually ignored in the early stages of product development and which may later introduce interaction barriers.

2. Case study: The LCAP system

Geovisualisation in the transport context has been employed in various ways as most data captured in monitoring transportation systems are geospatially referenced. For example, geovisualisations have been applied for communicating live traffic data so that commuters can plan their journeys more effectively (Goldsberry, 2008), for visualising historic traffic data (i.e. Incident Cluster Explorer), and in the context of real traffic management – a notable example being the incident management system (Lund et al., 2010).

Our case study is concerned with the London Congestion Analysis Program (LCAP), which monitors road network performance using link journey time data between pairs of Automatic Number Plate (ANPR) cameras managed by the Traffic Analysis Centre (TAC) at Transport for London (TfL). Data include vehicles' five-minute aggregated average travel times between a pair of ANPR cameras to reveal traffic congestion and to produce additional road network performance metrics (e.g. speeds, delays or journey time reliability). Data are stored in the LCAP system, which includes a visualisation tool called LCAP map viewer for map-based information on the exact location of traffic congestion. The LCAP system was developed internally by the TAC team to support work tasks; however, as we demonstrate in this paper, there are still user requirements that were not addressed.

3. Methodology

Geovisualisation research studies utilise different HCI methods to explore user requirements. Slingsby and Dykes (2012) suggest meetings, workshops and workplace-based evaluations. Lloyd et al. (2007) gather reference material (e.g. metadata) and conduct open-ended interviews – methods also suggested in Robinson et al. (2005) *work domain analysis* stage. Using a similar approach we first attempted to improve our understanding with respect to the transport context, and this involved exploring reference material (e.g. TfL publications and reports) on road traffic, road network performance monitoring and data congestion indicators. This stage supported the identification of potential users and also informed the design of the interview template for questioning the head of the corridor performance team within TAC, who also led the LCAP system design. The interview template that we developed for the second stage of user requirement gathering consisted of four parts:

- a) Open-ended questions about the organisational structure which aimed to gather more information on user responsibilities and tasks (e.g. draw organisational chart, describe team structure and duties).
- b) Open-ended questions about existing visualisation or additional software used by TAC for example, 'Do you have any systems for analysing and visualising Traffic Master GPS Data?'
- c) A demonstration of LCAP system guided by such questions as, 'Could you please explain how you are using the LCAP map viewer to visualise the relationship between traffic incidents data and link travel time?' and 'What features do you like/dislike the most?'
- d) Finally, we asked the user to describe how a new visualisation system would effectively support tasks and we provided sketchbooks to draw an imaginary new interface.

4. Results

Reviewing all relevant reference materials was an ongoing process that lasted several months and was conducted while working closely with the TAC team. During this period we found that there were important functions not supported by the LCAP system. An important problem with LCAP map viewer's thematic maps was that these provide information only for a specific time. A user in order to identify when congestion occurred has to investigate different time periods within a day. As a solution LCAP provides a pop-up line graph to show the traffic trend of each link (Figure 1), which increases dramatically the time spent on the task and user effort.

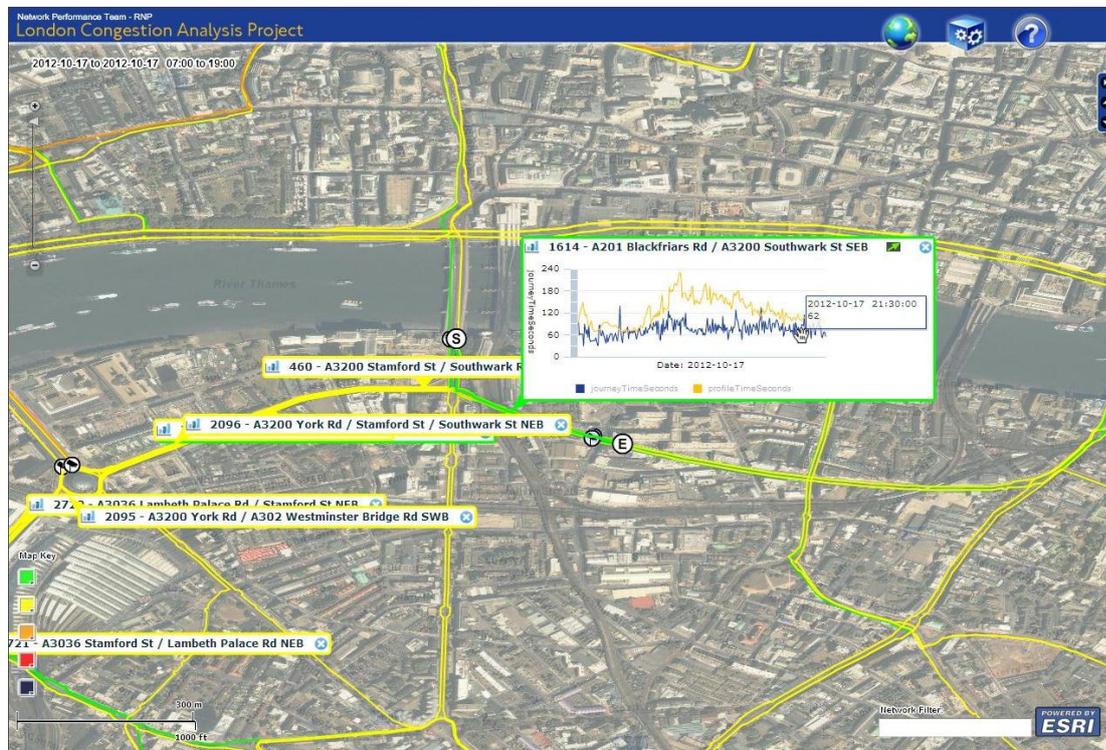


Figure 1. The existing LCAP Map viewer's thematic map (colour line representing level of journey time) and pop-up line graph function.

Therefore, a requirement for immediate design was the development of a geovisualisation which highlights congested areas and the congestion's spatio-temporal information. To address this requirement we developed the 3D wall map technique (Cheng et al., 2010) which shows the locations of traffic delays. The difference between base line defined by TfL and actual travel time was measured, as well as how the travel time changed within a day (Figure 2).

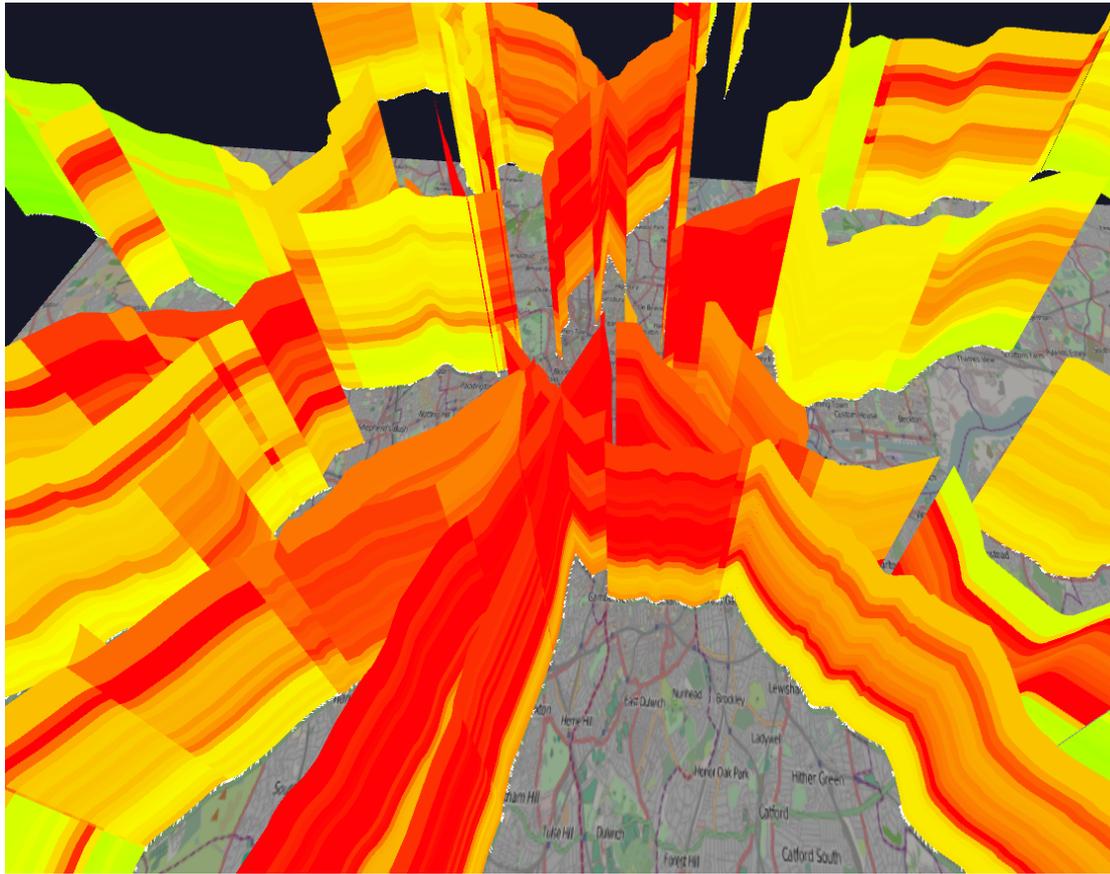


Figure 2. 3D Wall map early design (Cheng, 2010). The red colour represents traffic delays of more than 3 min/km, revealing congestion. Yellow represents traffic delays between 3 and 1 mins/km. Green represents traffic delays of less than 1 min/km.

The interview session – which lasted two hours, transcribed and analysed – revealed requirements which significantly improved the proposed 3D Wall map visualisation. During the interview it became clear that users needed a visualisation that shows congested areas instead of travel delay changes. To achieve this as shown in Figure 2 we established a new colour scheme (i.e. red with transparency to indicate the level of congestion) as a selective choice in the new interface.

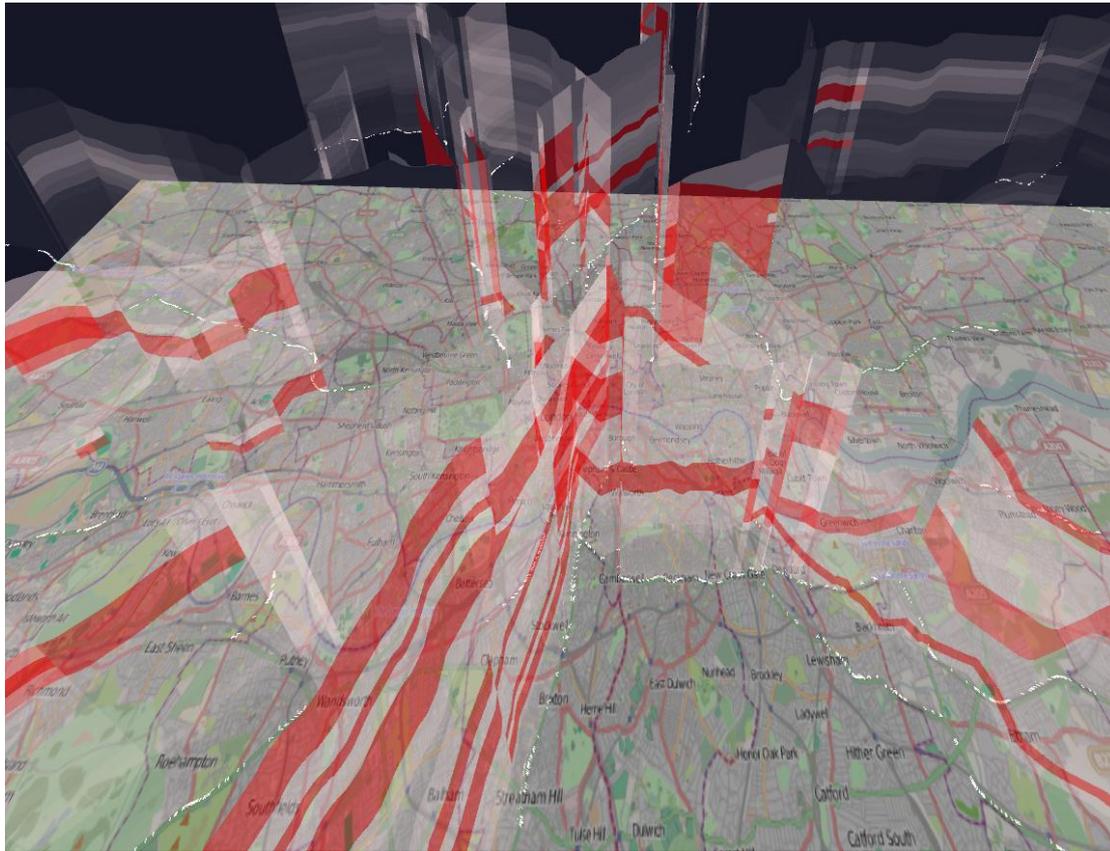


Figure 3. The wall map which high traffic delay areas are highlighted while the low traffic delay areas are faded out.

Another requirement was that the interface should support selection of traffic congestion data for different time periods (e.g. for a specific day and/or time of day), which we also incorporated into the new visualisation system as shown in Figures 4 and 5.

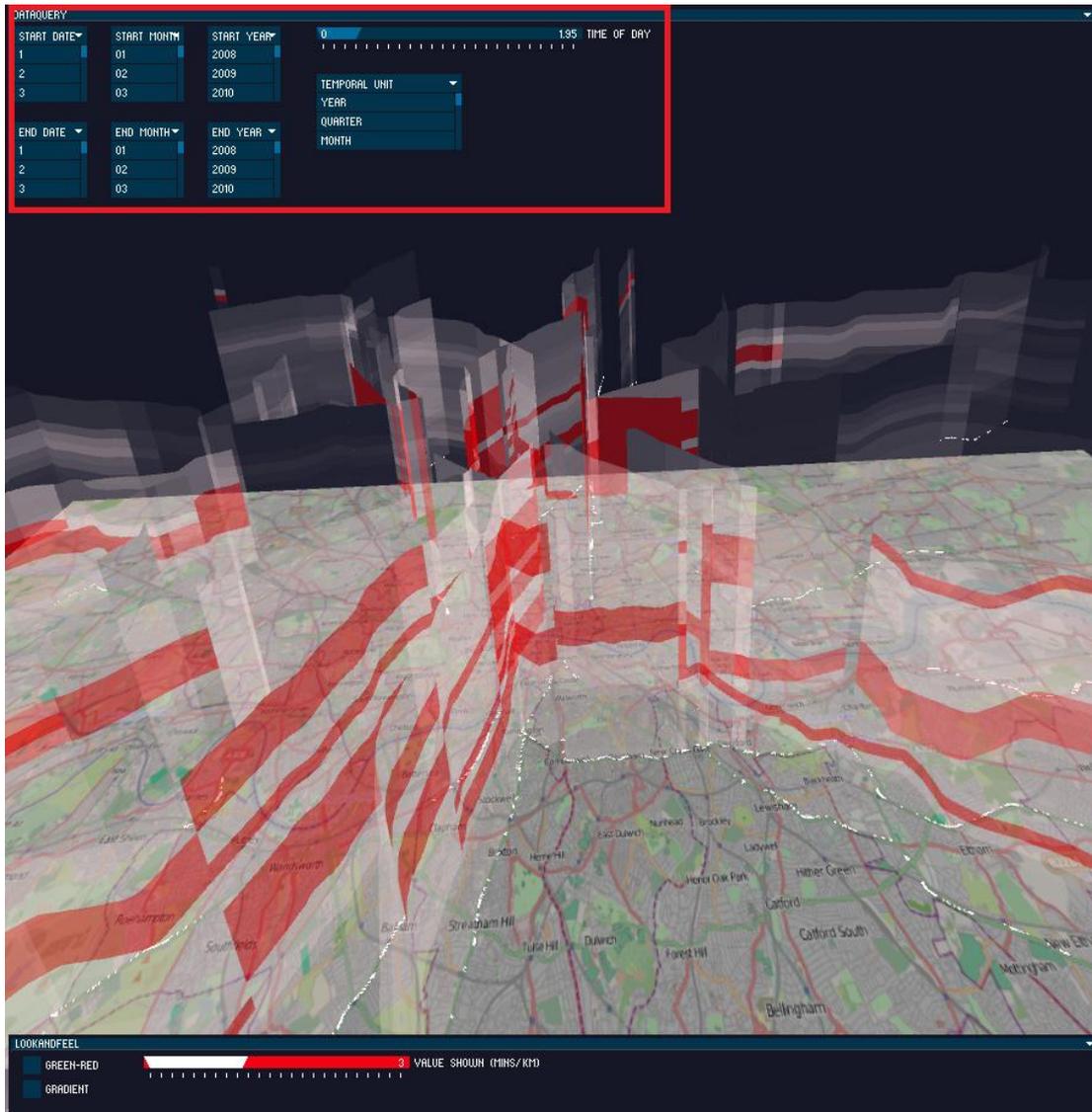


Figure 4. 3D Wall map user interface. A data query function (in the red rectangle) was added based on user requirements.

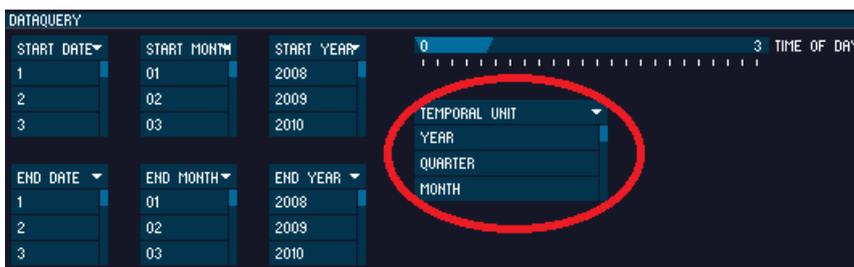


Figure 5. Data query function includes a temporal unit selection (in the red circle) based on user requirements.

The interview revealed that various levels of temporal aggregation (e.g. annually, quarterly, monthly, weekly) should be also provided so that users can more effectively understand the cause of traffic congestion occurrences (e.g. hour-based data may reveal congestion due to

accidents or adverse weather, while quarter-based data may reveal congestion due to changes of a road scheme). Thus a function was further added into the system, which allows users to compare between different levels of aggregation.

5. Conclusion

In this study we demonstrate how a preliminary user requirements analysis supported the design process of a novel 3D Wall map visualisation for expert traffic congestion analysis. Not only was the 3D Wall map designed to effectively support identification of congested areas and relevant spatio-temporal information, as a major user requirement, but additional functionality and interface improvements (e.g. colour scheme) were made to address further needs. We are currently expanding our design to include additional requirements for new tasks such as: providing summary statistics and diagrams for inclusion in the 'Road Network Performance Reports', which the TAC team prepares every three months and improving interface interactivity so that users can view both map-based data and the graphs they produce. In addition, we are currently interviewing more people from the TAC team to identify additional requirements, which will be incorporated in the design of the proposed visualisation system.

Notably, the LCAP map viewer's design is currently also being expanding by the TAC team. The focus is on adding functions to support new tasks rather than improving existing functions to better support work tasks. Although they have already acknowledged during the interview the limitations of the existing visualisation they still have not addressed this problem as a formal user requirements analysis was never undertaken. As demonstrated by previous studies, we seek to provide further evidence that an iterative UCD approach will effectively support the development of an effective visualisation for traffic congestion. Within this context, future work also includes testing the new system with users of the TAC team to evaluate whether it supports work tasks and identify any usability issues that would be subsequently redesigned to improve interaction.

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Biographies

Garavig Tanaksaranond is currently a PhD researcher in the STANDARD project (standard.cege.ucl.ac.uk), University College London. Her research topic is geovisualisation, focusing on the visualisation of road traffic congestion.

Artemis Skarlatidou is a Postdoctoral Teaching and Research Fellow at UCL, in the Extreme Citizen Science (ExCiteS) group. Her research focuses on Human-Computer Interaction aspects of Web GIS (usability, trust) and further expands to psychology, risk communication and philosophy. In her EngD she investigated how nuclear waste disposal information should be provided to lay people in the UK to improve public knowledge and

trust. She also developed trust guidelines to improve Web GIS trustworthiness for the nuclear waste disposal case, which currently expands in the public crime-mapping context (EPRSC Doctoral Prize Award).

Tao Cheng *is a Professor in GeoInformatics, director of SpaceTimeLab and the Course Director of MSc in GIS at UCL. She is the Principal Investigator, of amongst others, the Crime, Policing and Citizenship (CPC) and the Spatio-Temporal Analysis of Network Data and Route Dynamics (STANDARD) projects. Her research interests span network complexity, integrated spatio-temporal data mining, spatial-temporal data modelling and visualisation, and uncertainty and quality of geographic information, with applications in coastal zone management, environmental monitoring, epidemics and transport studies.*