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TimeSets for Uncertainty Visualisation

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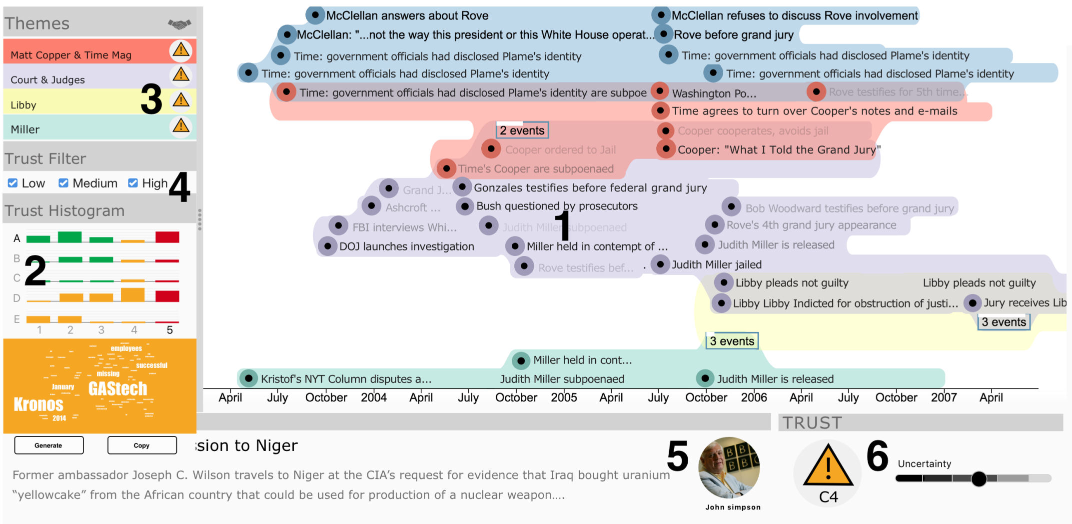

Figure 1: *TimeSets with uncertainty visualisation.*

1. Introduction

TimeSets consist of a timeline showing sequence of events displayed across a visualisation, while makings sense of sets relation among events in the timeline [NXWW15]. This study looked into extending TimeSets to accommodate Visualisation of trust and uncertainty as parts of its variables for events displayed across the timeline. The aim of the challenge is to build tools in the context of big data analytics that can be used to aid military operations through intelligence analytics and decision-making.

2. Related Work

Uncertainty and Trust has been the subject of less extensive research compared to data mining and extraction, while it is beyond the scope of this paper to provide a complete overview of research in Uncertainty and Trust, in the following section, we describe aspects of the research on Uncertainty and Trust propagation, we also review more recent literature on the role of Uncertainty and Trust and in Trust models and Finally, we briefly review finding from the research study carried out.

Some of the first attempts to quantify user perception of trust were carried out in a study by [CdHP11], although previous studies where geared towards identifying the sets of factors influencing trust, the author took the novel approach of quantifying the value of each trust factor in a given domain. The result of the study can enable visualisation interface developers to focus on key elements that influence trust and increase the trustworthiness of an interface.

The study carried out by [GHL15] looked into visual variables used to represent uncertainty. The paper reports on a study about the perception of graph edge attributes when uncertainty associated with each edge and the main edge attribute are visualised simultaneously using two separate visual variables, some of the results show that factors such as graininess, fuzziness and transparency depict uncertainty effectively.

Visual representation of uncertainty with focus on variables that can be used to depict uncertainty and trust in data is key to support the design study. An experiment carried out by [MRO*12] to determine the effectiveness of uncertainty variables such graininess, fuzziness and transparency led to some generalised conclusion by the author such as fuzziness and variable locations work very well in uncertainty visualisation, values and arrangement of variables

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are also an effective means of showing uncertainty, transparency and variable sizes are theoretically valuable for representing uncertainty.

Visualising uncertainty in other domains is also a key consideration for the design due to the wide range of digital devices used to access software?s and applications both in and outside the military industries. The study by [MKHM16] proposed a novel design quantile dotplots interface in the mobile context for presenting uncertainty in real-time transportation with main focus on transit arrival times. quantile and dotplots were shown to improve estimation of transit time arrival by end-users in a controlled experiment.

Another study by [CZC*15] looks into modelling and exploration in multidimensional data. The author presents an efficient visualisation and exploration approach for modelling and characterizing the relationships and uncertainties in the context of a multidimensional ensemble dataset. The author focuses more on simulation and analysis with some suggestion on using ensemble simulation to study uncertainty.

3. User Observation

Pair Analytics [AHFK11] was used to understand users perception of uncertainty and trust in data. *Pair Analytics* is an observational exploratory exercise carried out with the aim of capturing interaction between a subject and a controller. The excercise is carried out by two participants, the Subject Matter Expert (SME) and Visual Analytics Expert (VAE). The VAE plays the role of the observation controller/driver while the SME controls the VAE as the navigator in an exploratory data analysis task which was based around the analyses of data from [CGW14] mini challenge 1. The two participants were two ex-military analysts and the session lasted for about 3 hours each.

Figure 2: *The Subject Matter Expert (SME) examining a legacy version of TimeSets with the Visual Analytics Expert (VAE) depicting the [CGW14] mini challenge data in an observational, exploratory user study to enable visual data exploration*

Thematic analysis technique was used to analyse the data collected from the observation stage which included video recordings and interview transcripts. The following themes and patterns where derived from the result of the procedure carried out with the participants during the user observation.

1. Data source is a key factor to confidence.
2. Updated source of information affects information con?dence level over time.
3. Internal and known sources are more trusted than external sources.
4. Uncertainty and trust variables
5. High confidence information arranged above low confidence ones.

4. Design Workshops

Two design workshops were conducted as part of the research study to support the design ideas using the Design Sprint [BLW15]. There were 5 workshop participants, 2 senior researchers, 1 research assistant, 1 project manager, and an ex-army analyst. The design workshop started with an **Understand** stage that solicits users needs and help all stake holders come to a common understanding of the user requirement. The next stage is **Diverge**, which involved writing down scenarios in the context of situation, motivation and outcome by all 5 participants and using it to support the creation of 6 individual design ideas from each participant. All participants are then required to use the 6 ideas to create a storyboard based on the user requirements. This was followed by a silent critic session where each storyboard from the team was posted on a board and all team members went around with dot stickers to choose which ideas they liked the most in the form of a vote by placing dot stickers on them. The last stage of the design sprint process is the **Converge**, which involved creating a final storyboard based on a collective effort and ideas from the participants. The final storyboard was created on a whiteboard in the form of a comic drawing with the users actions in each frame as seen in Figure 3.

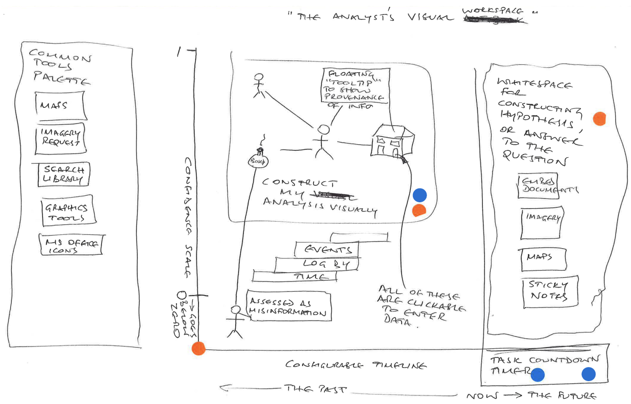

Figure 3: *Final Story Board*

5. Uncertainty Visualisation in TimeSets

Guided by the outcomes from the design workshop, TimeSets was extended to support uncertainty visualisation as detailed below:

1. Transparency to indicate uncertainty in events by using opacity to gauge level of trust in data. High opacity indicates high confidence while low opacity shows low confidence in data as seen in fig 1 section 1.

2. Trust Histogram to indicate the 5x5x5 trust model in the form of a matrix. This matrix provides an overview of the number of events of each uncertainty level (fig 1 section 2).
3. Trust Indicators on set Themes to show the average level of trust in a group of events. This is indicated by the the triangle and colour of the triangle with green standing for high level of trust and red for low level of trust as seen in fig 1 section 3
4. Trust Filter used to filter only events with specific levels of trust based on three categories, low, medium and high as seen in fig 1 section 4.
5. Icon/Logo display as part of article viewer which increases trust in data as supported by the result from the user observation from the Initial Findings as seen in fig 1 section 5
6. User modified slider that can be used to adjust the level of Trust and Uncertainty attached to an and event or data as seen in fig 1 section 6

6. Evaluation

The three main Evaluation approaches widely used to create systems that are easy and straightforward to use are Accessibility, usability and user experience. Evaluation was defined by the ISO 9241 standard as the level at which a product of software can be used effectively and efficiently to achieve specific goals [Org].

Due to time constraint, no formal evaluation was carried out on the new version of Timesets as required by the [Org] standards. An informal evaluation was conducted with an ex-army analyst, with the following feedbacks:

1. For the colouring of the uncertainty histogram matrix (Figure 1 part 2), the analyst suggested that red and green to cover the top left and bottom right corners respectively, with amber forming the diagonal from the top right to the bottom left.
2. The analyst liked the feature of filtering information by trust level and doing so by selecting multiple combination of levels rather than a range so that they could, for example look at high and low trust only.
3. The analyst thought article displayed in a single location at the bottom of screen was more useful than using separate windows, even though only one article could be viewed at once.
4. The analyst found the colouring to be a bit confusing, because red/amber/green colour combinations were used for uncertainty level but the same colours were also used for themes in TimeSets. He felt the latter did not function as anything other for aesthetic purpose.

7. Conclusion

The literature review, user observation and design sprint workshop enabled the researchers to gain valuable insight into users perception of uncertainty and trust. The paper has explored the different ways in which uncertainty is being handled during decision making in relation to data analysis while also identifying and recommending some effective methods and techniques of communicating uncertainty and trust in data during analysis and decision making by identifying key elements that constitute uncertainty and different ways they can be communicated across the digital spectrum in the military sector.

Acknowledgments

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