View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by City Research Online

Henkin, R., Slingsby, A. & Dykes, J. (2015). Exploring Temporal Granularities with Visualization. Paper presented at the VIS 2015, 25-10-2015 - 30-10-2015, Chicago, USA.

CITY UNIVERSITY LONDON

EST 1894

City Research Online

Original citation: Henkin, R., Slingsby, A. & Dykes, J. (2015). Exploring Temporal Granularities with Visualization. Paper presented at the VIS 2015, 25-10-2015 - 30-10-2015, Chicago, USA.

Permanent City Research Online URL: http://openaccess.city.ac.uk/12332/

Copyright & reuse

City University London has developed City Research Online so that its users may access the research outputs of City University London's staff. Copyright © and Moral Rights for this paper are retained by the individual author(s) and/ or other copyright holders. All material in City Research Online is checked for eligibility for copyright before being made available in the live archive. URLs from City Research Online may be freely distributed and linked to from other web pages.

Versions of research

The version in City Research Online may differ from the final published version. Users are advised to check the Permanent City Research Online URL above for the status of the paper.

Enquiries

If you have any enquiries about any aspect of City Research Online, or if you wish to make contact with the author(s) of this paper, please email the team at publications@city.ac.uk.

Exploring Temporal Granularities with Visualization

Rafael Henkin*
giCentre
giCentre City University London

Aidan Slingsby*
giCentre
giCentre City University London

Jason Dykes*
giCentre
giCentre City University London

ABSTRACT

Time can be expressed and aggregated into concepts called granularities. Granularities are defined in a structure with their rules of conversion that may take the form of trees or graphs, thus it's possible to design tools that dynamically explore different granularities that might reveal patterns hidden in other levels. We described an intial investigation of the use of interactive visualization techniques for that purpose and define future work to be done.

1 INTRODUCTION

Time can be considered as a continuous phenomenon, but it is often discretised and aggregated into different *temporal granularities* [3] – discrete units of time. These may refer to time ranges of continuous time (e.g. binning time into hours or days) or may refer recurring units that are cyclic (e.g. the hours over a 24-hour period). These affect the *scale* at which time is considered, which in turn affects visual representations of data and the results of temporal analysis.

Choosing appropriate temporal scales of analysis for the domain and task at hand is therefore important, as results may depend on this. Appropriate temporal granularities depend on the domain of the phenomenon under study and the analytical task. Crime analysts might both look for diurnal patterns of crime and longer terms trends. Animal movement ecologists may use temporal granularities that relate to the animal's lifecycle when analysing movement tracks from GPS loggers.

Therefore, it's important to design tools that take advantage of the structure of granularities to solve these tasks [1]. We propose to investigate the use of interactive visualization techniques to dynamically explore granularity structures and their temporal aspects.

2 TEMPORAL GRANULARITIES

Granularity structures define the possible units of expression and aggregation and the rules of conversion. One example is a linear structure where the lowest unit of time is milliseconds and the highest is hours, with seconds and minutes between and formulas defining the conversion from one to another. Objects and events can then be expressed and compared by applying the rules of conversion between units. One example of comparison is calculating the temporal distance between events using different units.

Another granularity structure could include hours and days, with the possibility of aggregating days by weeks, weekdays or weekends, without a clearly defined hierarchy. In this example, weekdays and weekends would be examples of temporal granularities that do not follow simple formulas for conversion.

Besides expressing order of occurrence, granularities can also be used to group events and objects and find patterns of occurrence. For example, a temporal task might be counting the number of events occurring every hour.

*e-mail: {rafael.henkin.1,aidan.slingsby.1,j.dykes}@city.ac.uk

3 VISUALIZING GRANULARITIES

Data expressed in different granularities can be visualized independently using appropriate techniques for each. However, tools can be designed with dynamic interactions taking advantage of that structure and user knowledge as many temporal granularities are not exclusive to domains. There are several possible approaches to design a dynamic visualization method that supports multiple granularities. One way is using multiple views [9], where visualization techniques applied to different granularities can be shown concurrently with interactions between them. Composite and hierarchical displays [7, 10] are also alternatives to combine multiple techniques. The approach of visual aggregations explored by [4] define visual aggregations as representations of aggregated data items with the purpose of facilitating visualization when the dataset is too large, producing visual clutter. This could also be applied to temporal granularities, where each granularity can be seen as aggregated data items.

Besides higher level frameworks and guidelines, several traditional visualization techniques have been expanded to work with aggregated data, such as parallel coordinates [5], along with some techniques developed specifically for granularities like temporal summaries [8]. For granularities, however, the appropriate visualization technique to be applied may depend on both the type of temporal task being solved and temporal aspects of the granularity.

These aspects are concerned with the nature of the scale used to visualize time, such as discrete or ordinal scale, the use of instants or intervals as the basic primitive used in visualization, the linear or cyclic arrangement of time and the view of time as a strict ordered series of events or branching events, where the data does not provide a single "true" path in time.

We propose to explore the space of switching granularities and finding out appropriate interactive visualization techniques based on the tasks and temporal aspects of the granularities.

4 CASE STUDY

An initial exploration of temporal granularities with visualization is being done within the scope of analysis of animal movement [6], where GPS tracks are collected at the granularity of seconds. The objective of the case study is to help answering time related questions in a spatial context. More specifically, we are looking at the relation between the temporal attributes of trips away and back to the nest and the nest bouts, which are the correspondent time spent on the nest. Examples of questions asked *"are there generally a number of consecutive longer trips followed by shorter trips?"* or *"do trips preceding a nest bout have an influence on the duration of it?"*.

The initial exploration of visualization resulted in a doubled bar chart with the duration in hours of trips and nest bouts of a single bird as lengths of the bars (see fig. 1). The initial and ending time of each trip and bouts are also shown in the timeline. Colour in the bars is used to trace the overall direction of the movement, while colour in the central vertical axis defines the periods for each breeding status of the bird. This is intended to show the behaviour of the bird when it's incubating or hatching an egg, for example, or the other possible breeding statuses.

A rearrangement of this timeline is also being experimented with (fig. 2), replacing the discrete temporal scale with a simple ordinal scale showing the sequence of trips and nest bouts paired with each other. In this case, the temporal context, that is, the actual absolute time when the events occur, is lost. However, this arrangement might be better for comparing the duration of trips and nest bouts. In this chart, it's also possible to select the trips, as an initial interaction to analyse only a subset of trips.

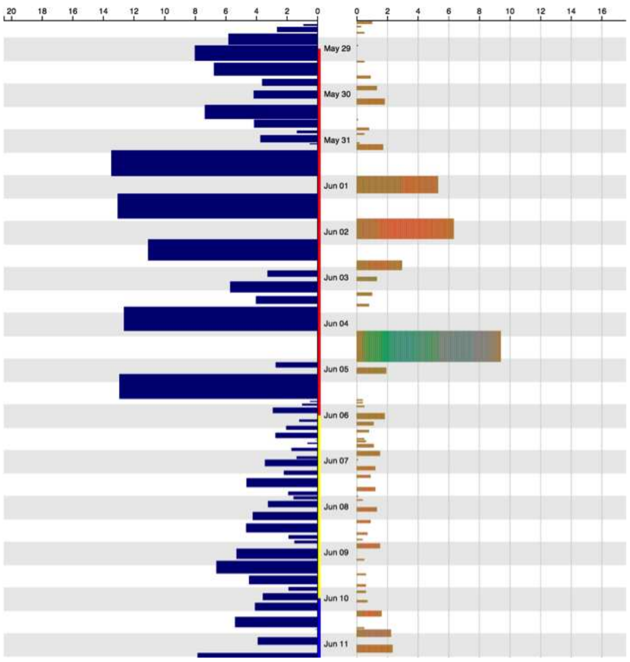

Figure 1: The timeline with the duration of trips and nest bouts..

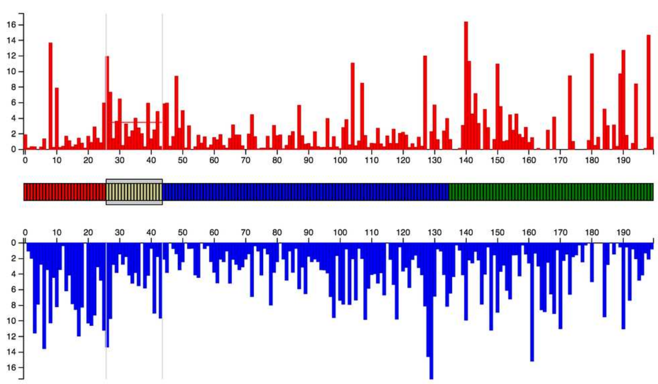

Figure 2: Trips and nest bouts shown sequentially with an ordinal scale.

5 Conclusion and future work

We have described temporal granularities and how the resulting structure can be visually explored to help solving temporal tasks. We also presented an initial design experiment on which we have been working with animal movement researchers.

As this is an initial work, these are objectives for future work:

- examine the application of different visualization techniques for different granularities, while allowing the user to dynamically change between granularities and techniques
- investigate the appropriate techniques to show different granularities together
- investigate how uncertainty in the data affects the representation and task solving

It would then be possible to identify the most effective interactions for some granularities. We can also analyze and classify the techniques based on the tasks they intend to solve, such as looking for cycles, repeating patterns or simply counting occurrences.

Acknowledgements

The authors wish to thank E. E. Van Loon. The data we used for our research was kindly made available by UvA-BiTS (http://www.uva-bits.nl/). R. H. acknowledges funding from CAPES, process 9076/13-1.

References

[1] W. Aigner, S. Miksch, H. Schumann, and C. Tominski. *Visualization of Time-Oriented Data*. Springer London, 2011.

[2] W. S. Cleveland. *Visualizing Data*. Hobart Press, 1993.

[3] C. Dyreson, W. Evans, H. Lin, and R. Snodgrass. Efficiently supporting temporal granularities. *IEEE Transactions on Knowledge and Data Engineering*, 12(4):568–587, 2000.

[4] N. Elmqvist and J. D. Fekete. Hierarchical aggregation for information visualization: Overview, techniques, and design guidelines. *IEEE Transactions on Visualization and Computer Graphics*, 16(3):439–454, 2010.

[5] Y.-H. Fua, M. O. Ward, and E. a. Rundensteiner. Hierarchical parallel coordinates for exploration of large datasets. *Visualization Conference, IEEE*, pages 43–50, 1999.

[6] R. Henkin, A. Slingsby, and E. van Loon. Designing Interactive Graphics for Exploring Sea-Bird Foraging Trips. In *Workshop on Analysis of Movement Data at the Eighth International Conference on Geographic Information Science (GIScience 2014)*, 2014.

[7] W. Javed and N. Elmqvist. Exploring the design space of composite visualization. In *IEEE Pacific Visualization Symposium 2012, PacificVis 2012 - Proceedings*, pages 1–8. Ieee, Feb. 2012.

[8] T. D. Wang, C. Plaisant, B. Shneiderman, N. Spring, D. Roseman, G. Marchand, V. Mukherjee, and M. Smith. Temporal summaries: Supporting temporal categorical searching, aggregation and comparison. In *IEEE Transactions on Visualization and Computer Graphics*, volume 15, pages 1049–1056, 2009.

[9] M. Q. Wang Baldonado, A. Woodfruss, and A. Kuchinsky. Guidelines for using multiple views in information visualization. In *AVI '00 Proceedings of the Working Conference on Advanced Visual Interfaces*, pages 110 – 119, 2000.

[10] J. Yang, M. O. Ward, and E. A. Rundensteiner. Interactive hierarchical displays: A general framework for visualization and exploration of large multivariate data sets. In *Computers and Graphics (Pergamon)*, volume 27, pages 265–283, 2003.