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Solving Problems with Visual Analytics

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Abstract

Visual analytics is an emerging research discipline aiming at making the best possible use of huge information loads in a wide variety of applications by appropriately combining the strengths of intelligent automatic data analysis with the visual perception and analysis capabilities of the human user. The major goal of visual analytics is the integration of these disciplines into visual analytics to acquire well-established and agreed upon concepts and theories, combining scientific breakthroughs in a single discipline to have a potential impact on visual analytics and vice versa. In a session at FET'11, the leaders of the thematic working groups of the recently finalised FET Open coordination action VisMaster CA presented the scientific challenges that were identified in the visual analytics research roadmap, and the connection between the various disciplines and the broader vision of visual analytics. This article contains excerpts from this research roadmap to motivate further research in this direction within FET.

Keywords: Visual analytics; Research roadmap; Information visualisation; Data mining; Data management; Cognitive science; Geo-visual analytics

1. Introduction

In response to the rapidly increasing amount of data that our world faces today, the VisMaster CA project, funded by FET Open, successfully created a European community to perform and promote research in visual analytics throughout Europe. The project also created a visual analytics research roadmap [1] that highlights several recommendations for further research, collaboration, and policies in this direction. The following paragraphs contain excerpts and a figure from this research roadmap to introduce the field and motivate the next steps in this research direction.

First of all, it is evident that virtually every branch of industry or business, and any political or personal activity, nowadays generates vast amounts of data. Making matters worse, the possibilities to collect and store data increase at a faster rate than our ability to use it for making decisions. The overarching driving vision of visual analytics is to turn the information overload into an opportunity: the goal of visual analytics is to make our way of processing data and information transparent for an analytic discourse. The visualisation of these processes will provide the means of examining the actual processes instead of just the results, and will ultimately improve our knowledge and our decisions.

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Visual analytics is an emerging research discipline aiming to make the best possible use of huge information loads in a wide variety of applications by appropriately combining the strengths of intelligent automatic data analysis with the visual perception and analysis capabilities of the human user. The integration of these disciplines into visual analytics will result in a set of well-established and agreed upon concepts and theories, allowing any scientific breakthrough in a single discipline to have a potential impact on the whole visual analytics field. In return, combining and upgrading these multiple technologies onto a new general level will have a great impact on a large number of application domains.

The session titled "Solving Problems with Visual Analytics" at FET'11 in Budapest featured the leaders of some of the thematic working groups of the recently finalised FET Open coordination action VisMaster CA [2]. They presented the scientific challenges that were identified in the visual analytics research roadmap, and the connection between the various disciplines and the broader vision of visual analytics. They invited the attendees of the session to join the on-going interdisciplinary European visual analytics community, propose new connections to other communities, and join a lively discussion on the next steps of this emerging scientific field.

2. Visual Analytics

Visual analytics is not easy to define, due to its multi-disciplinary nature involving multiple processes and the wide variety of application areas. An early definition was "the science of analytical reasoning facilitated by interactive human-machine interfaces"[3]. However, based on current practice, a more specific definition would be: "Visual analytics combines automated analysis techniques with interactive visualisations for an effective understanding, reasoning and decision making on the basis of very large and complex datasets" [1].

As further explained in [1], we can elaborate on this definition to state that visual analytics is the creation of tools and techniques to enable people to:

- Synthesise information and derive insight from massive, dynamic, ambiguous, often conflicting data.
- Detect the expected and discover the unexpected.
- Provide timely, defensible, and understandable assessments.
- Communicate these assessments effectively for action.

The visual analytics process combines automatic and visual analysis methods with a tight coupling through human interaction in order to gain knowledge from data. Fig. 1 shows an abstract overview of the different stages (represented through ovals) and their transitions (arrows) in the visual analytics process. The visual analytics process aims at

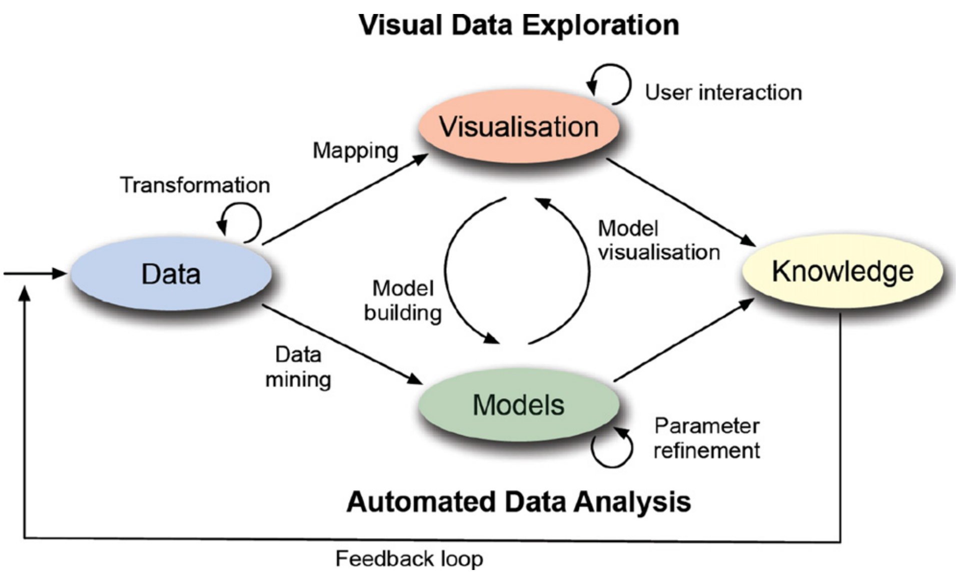

Fig. 1. The visual analytics process is characterised through interaction between data, visualisations, models about the data, and the users in order to discover knowledge [1].

tightly coupling automated analysis methods and interactive visual representations. The guide to visually exploring data "Overview first, zoom/filter, details on demand", as proposed by Shneiderman [4] describes how data should be presented on screen. However, with massive datasets at hand, it is difficult to create an overview visualisation without losing interesting patterns, which makes zooming and filtering techniques effectively redundant as the users is given little information of what to examine further. In the context of visual analytics, the guide can usefully be extended to "Analyse first, show the important, zoom/filter, analyse further, details on demand" [5] indicating that it is not sufficient to just retrieve and display the data using a visual metaphor; rather, it is necessary to analyse the data according to its value of interest, showing the most relevant aspects of the data, and at the same time providing interaction models to get details of the data on demand.

3. The Visual Analytics Research Roadmap

The session at FET'11 introduced the Visual Analytics Research Roadmap [1], the major outcome of the EU project VisMaster CA. The keynote of the session pointed out several of the key recommendations, which will be described in the remainder of this section. The other presentations gave more details on related communities of visual analytics, namely data management, data mining, cognitive science and perception, spatio-temporal visual analytics, infrastructures, and evaluation. These communities and their contribution to visual analytics are further described in the research roadmap together with a more detailed explanation of the recommendations, challenges, and opportunities for each community as well as for the entire field of visual analytics.

3.1. Recommendation 1: Develop the Foundations of Visual Analytics

The umbrella, under which the various efforts in the EU can be integrated, has to be further entrenched by the EC. This could be established through a FET Proactive Topic that funds several projects in visual analytics, implementing the vision that this research roadmap lays down. In addition, FET Open basic research schemes or comparable national instruments should support specific basic research projects in visual analytics as a next step.

3.2. Recommendation 2: Foster Interdisciplinary Research

The fastest path to new solutions to highly complex problems, as targeted by visual analytics, is the promotion of interdisciplinary research projects where heterogeneous teams address real-world problems and develop visual analytics methods and tools that help in investigating and solving these problems.

3.3. Recommendation 3: Develop a Visual Analytics Infrastructure

Researchers in databases, analytics, visualisation and communication should be given incentives to work together to iterate on the design of a conceptual architecture for visual analytics applications. This will avoid an explosion of partial solutions to the overall infrastructure problem and also situations in which specialists in one domain implement another domain's modules.

3.4. Recommendation 4: Integrate Visual Analytics with Applications

Drawing on the examples of successful prototypes, domain experts should evaluate their potential need for visual analytics technology, possibly with the assistance of knowledgeable researchers and developers, and communicate this need through the appropriate channels. It is advisable to focus on small, incremental improvements and use case studies of successful pilot projects to generate broader support for and acceptance of visual analytics in various application fields.

3.5. Recommendation 5: Evaluate Visual Analytics Techniques and Systems

Visual analytics methods can be evaluated in a variety of ways, ranging from informal user studies to studies of the adoption in practice. Methodologies for evaluation can be improved significantly, and this will provide means to obtain results about the quality of visual analytics artefacts more efficiently.

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