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Policy-making in a Complex World: Can Visual Analytics Help?

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ABSTRACT

As government are moving their focus from service provision to regulation, socio-economic issue are revealing more complex than ever to regulate. Traditional top-down and linear models for dealing with risks proved uneffective, as the financial crisis has shown. In recent years, new ICT tools have emerged that take better account of complexity and wicked problems, namely by augmenting human intelligence rather than trying to substitute for it: for example, social networking, crowdsourcing, social simulation and visual analytics. Yet these tools are far from being widespread and the related research fields are still fragmented.

The CROSSROAD project, co-funded by the European Commission, aims at drawing a common research agenda in the field of ICT for Governance and Policy Modelling, including approaches such as visual analytics, that enable the identification of unexpected risks and the augmenting of human intelligence in dealing with large amounts of data. This paper presents the approach and the first results of the project, with the aim to start a wider discussion with the visual analytics community on future research issues.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Line and Curve Generation).

1. Introduction

The role of government has substantially evolved over the last thirty years. Broadly speaking, it has changed from a government that "rows" to a government that "steers": while its role in service provision has diminished, its regulation activity is continuously growing. As the OECD review puts it: "*Government has a larger role in the OECD countries than two decades ago. But the nature of public policy problems and the methods to deal with them are still undergoing deep change. Governments are moving away from the direct provision of services towards a greater role for private and non-profit entities and increased regulation of markets. Government regulatory reach is also extending in new socio-economic areas. […] This expansion of regulation reflects the increasing complexity of societies.*" [OECD05].

But regulation proves to be an increasingly challenging task, as the recent financial crisis has shown. The world has become increasingly interconnected, complex, and fast-evolving: the effects of individual behaviour and of policy choices are much less predictable. In fact, unpredictability and complexity are two distinguishing characters of our society, as widely recognized in the literature about complexity science, chaos theories and non-linear systems. We are increasingly dealing with highly improbable events and "wicked problems" [Chu67], which are outside the range of predictability based on past behaviour [Wla09].

The paradox is that at the same time, the amount of data available to governments for making sense of the socio-economic environment has increased exponentially, either provided through sensors, such as with pervasive computing and Internet of Things, or through "crowdsourced" citizens' reports, such as in the case of wildfire reports via Twitter. Yet governments clearly struggle to make sense of such large amounts of data.

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The European Commission has decided to invest heavily in research on these areas, through the research priority on "ICT for Governance and Policy Modelling". In particular, the CROSSROAD project has been funded to set the research agenda of ICT for Governance and Policy Modelling, and this paper is a first step in this direction by reaching out to specific research communities as it presents the first results of the project in order to stimulate discussion within the scientific community of Visual Analytics.

The structure of this paper is as follows: Section 2 presents the focus and background in ICT for Governance and Policy Modelling and the approach of the CROSSROAD project to creating the roadmap. Section 3 provides the first insight into Visual Analytics and its role for Governance and Policy Modelling leading to Section 4 that concludes this paper.

2. Background

ICT has traditionally offered and promised opportunities for better decision support. In particular, ICT has enabled advanced modelling of large amounts of data, in order to monitor and anticipate risks. Forecasting tools and applications are widely used to monitor complex societal issues such as climate change and financial regulation [Gil76]. Tools based on system dynamics extend the modelling approach to include mutual causal loops and a more systemic view [Ste00]. These tools are largely based on modelling causal relationships and human behaviour based on historical data and are fundamental tools to manage risks under normal Gaussian distribution.

However, these tools fail short to serve the purpose of risk assessment and decision support on so-called "wicked problems", or "Black Swan" [Tal08], which are probably those most in need of being anticipated and regulated. In fact, it appears that such linear models are unable to deal with unpredictable events and crisis – which are precisely the kind of events where governments' role is most important. For example, there is a strong case [Wla09] that the reason of the financial crisis resides in the excessive reliance by decision-makers on mathematical models, which do not account for complexity and unpredictability.

In order to deal with unpredictability, different approaches to ICT applications should be used, that are able to leverage the best of human expert judgement. We need for tools that take into account the non linear nature of wicked problems, that help making sense of large amount of data, and that are able to leverage and augment human intelligence in Engelbart [Eng62] sense, rather than substituting for it.

The issue is not whether the best decisions are based on quantification and numbers, or whether given an uncertain future, decisions should be based on the intuitive beliefs and experience of human. The issue is to make best use of both approaches in an integrated way – while so far there has been an over-reliance on linear mathematical models.

In this sense, three ICT application domains appear particularly promising:

- **Mass collaboration**: web tools that are able to identify and leverage the maximum expertise dispersed "in the crowd"
- **Bottom-up and non-linear modelling approaches**, such as agent-based models and societal simulation, which take into account reflexivity and systemic interrelations
- **Applications for augmenting human intelligence**, that are able to facilitate and increase the capacity of experts

This research priority deals with applications of ICT that improve the effectiveness of public policy-making, in particular along three objectives:

- **More evidence-based**: making sure that policy decisions are based on the best evidence available. So far, the main tool to ensure this is by commissioning studies or creating expert's advisory committee
- **More timely**: making this evidence available as much as possible in real time. So far, the main way to ensure timeliness is relying on hierarchical decisions.
- **More participative**: making sure that issues are widely understood and shared, both as a democratic goal and in order to ensure the implementation of public goals. Traditionally, the main tools used are large-scale consultation and surveys.

Traditionally, these goals have been considered as alternative and incompatible. Urgent decisions should be taken hierarchically and can't be based on slow expert advice or long consultation. Scientific evidence cannot not be collected through an open discussion, but by selected "experts" and in due time. Participation is deemed to be slow and not evidence-based.

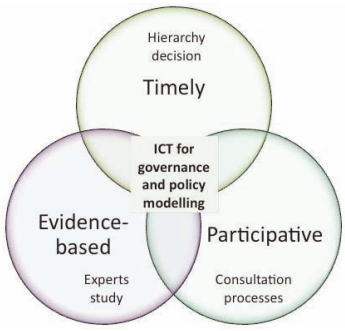

Figure 1: *The different objectives of public decision making.*

In this context, ICT tools for Governance and Policy Modelling play a fundamental role in reaching these goals, not only by providing tools that facilitate the achieving of each goal separately, but by reducing the tradeoffs between the different goals.

In recent years, many (web-based) projects [HBF*09] [Osi08] have been launched which are able to enable better decision-making, raise the level of the discussion, and bring additional insight, by opening up the discussion to a wider constituency, and by blurring the boundaries between experts and citizens insights.

Firstly, evidence-based policy making has been facilitated by a plurality of tools:

- Social simulation, multi-agent modelling tools, system dynamics analysis tools are able to simulate events and the impact of specific decision, taking into account not only forecasting of linear behaviours but systemic effects, that include complex, reflective interaction between interdependent agents
- Opinion mining tools enable the leveraging of huge amounts of data, uncovering patterns and unexpected insights
- Argument mapping tools such as Debategraph [Deb10] enable better structuring of the discussion around evidence-based concepts
- Mass collaboration tools such as IBM's "Innovation Jam" enable leveraging the unique insight of the individual users/ citizens/ employees
- Collaborative filtering tools, such as Peertopatent rating of evidence, enable the most robust evidence to emerge from distributed efforts

Secondly, many tools have emerged to make policy decisions more participated:

- Collaborative tools such as blogs and social networks enable citizens to express their concerns, rate government behaviour, help each other and create pressure groups around very specific issues
- Ideas-gathering exercises such as IBM's "Innovation Jam" [IBM10], "1000 ideas para sanidad publica" stimulate creativity in solving social problems
- Collaborative analysis tools such as peertopatent.org and stimuluswatch.org open up the analysis of complex problems to a wider constituency, beyond the "usual suspects", and ensure the transparency of public decision making
- Visualisation tools such as gapminder.com and IBM's ManyEyes enable wider understanding of complex social problems both towards policy-makers and citizens, lowering the barrier to participation
- Serious gaming and social simulation tools are able to elicitate the systemic impact of policy decisions by engaging

Thirdly, timeliness of decisions has also been improved:

- Complex system modelling are able to anticipate unexpected phenomena and ensure early warning of unexpected problems
- Mass collaboration tools have been used often in disaster emergency relief situations: Twitter was instrumental in mapping wildfires in California and informing about power outage in Vermont in 2008.

However, these tools are far from maturity and are not yet making a substantial impact in the quality of policy-making. Existing tools work at small scale and are resource intensive, and research is fragmented between disciplines.

The CROSSROAD project, lasting the whole of 2010, aims to build a shared research roadmap on ICT for government and policy modeling, by bringing together and providing a systematic view of existing separate research streams. In doing so, it adopts a holistic and policy-oriented approach to Technology Roadmapping [PFP03], including a foresight element by combining roadmapping with scenario building techniques. This is considered more appropriate for holistic roadmaps focused on highly complex multi-layered and multi-players domains. Accordingly, the project is at the time of writing (March 2009) drafting the State of the Art of research and implementation. It will then develop Innovative Scenarios of how policy making should happen in 2030, and carry out a Gap Analysis on the existing gaps to achieve the opportunities and avoid the risks. From this Gap Analysis, research challenges will be identified which will for the basis for the structured research roadmap.

The CROSSROAD approach to roadmapping is consistently open and iterative. Thematic experts from different disciplines such as economics, computer science, design, human-computer interaction, mathematics, physics, sociology are involved all through the project. Early results are released publicly for public review, through commentable versions on the website [CRO10].

The scope of the project covers different research fields such as:

- Open Government Information and Intelligence for Transparency
- Social Networks, Citizens Engagement and Inclusion
- Policy modeling, Simulation and Visualization
- Identity, Privacy and Trust in Governance
- Future Internet for Collaborative Governance

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3. Visual Analytics in Governance and Policy Modelling

3.1 Scope

Visual analytics appears as a highly relevant research area in the context of ICT for Governance and Policy Modelling, in particular as a tool to augment individual expertise and facilitate collaboration among a wider set of competences. Visualization is no longer considered as the final output of the analysis, but rather as a tool to explore and interrogate data. It allows to open up the "black box" of visual representation, unpacking the access to the data and allowing more in depth and dynamic interrogation of those data.

Taking into account that today, data is created and published at an incredible rate and the ability to collect and store the data is increasing at a faster rate than the ability to analyze it, Visual Analytics is characterized as an emerging area of research and practice that aims at integrating the outstanding capabilities of humans in terms of visual information exploration and the enormous processing power of computers to form a powerful knowledge discovery environment [ABM07], allowing them to make well-informed decisions in complex situations [HA08].

The goal is not only to find answers to the research question on hand, but to discover new questions. This is why visual analytics is one of the key fields to make sense of wicked problems. The overarching driving vision of Visual Analytics is to turn the information overload into an opportunity: Just as information visualization has changed our view on databases, the goal of Visual Analytics is to make our way of processing data and information transparent for an analytic discourse [KAF08]. In this end, the basic idea of Visual Analytics is to visually represent the information, allowing the human to directly interact with the data to gain insight, draw conclusions, and ultimately make better decisions [HA08].

Visual Analytics is an inherently multi-disciplinary field [ABM07], [KAF*08], [TC05] that aims to combine the findings of various research areas as Human-Computer Interaction (HCI), Usability Engineering, Cognitive and Perceptual Science, Decision Science, Information Visualization, Scientific Visualization, Databases, Data Mining, Statistics, Knowledge Discovery, Data Management & Knowledge Representation, Statistics, Interaction, Geospatial Analytics, Graphics and Rendering.

The work carried out within the CROSSROAD Project on the State of the Art of Visual Analystics is highly based on the roadmapping effort carried out within the VisMaster Project [KK07].

3.2 Taxonomy

Within the developed taxonomy for ICT for Governance and Policy Modelling, the specific field of Visual Analytics has been segmented for the purposes of the CROSSROAD Project as follows:

Table 2: *Visual Analytics Taxonomy Extract*

Research Sub-area	Definition
Visual Information Foraging and Design	Theories and applications trying to automatically understand how human users search for information and how visualization story-boards and scenarios should be designed in order to cover their needs.
Information Visualization and Interaction	Visual representations and interaction techniques including the principles for depicting information, new visual paradigms, statistical graphics, geospatial visualizations, aesthetics and animation, the science of interaction, and approaches for generating visualizations and interactions in multiple user interfaces and devices.
Analytical Reasoning	Analytical reasoning techniques and tools via which users obtain deep, high-quality insights that directly support situation assessment, planning, and decision making with a limited investment of the analysts' time.
Collaborative Analysis and Intelligence	Approaches that enable collaborative analysis of visualizations, gaining common ground and building on each other's findings. Awareness techniques, in which the interactions of one collaborator on a visualization are visible to other collaborators viewing the data items in their own visualizations or views of the data.
Visualization Evaluation	Methodologies and tools to systematically evaluate the impact, worth, and significance of a visualization approach such as visualization quality, measurement of the effectiveness of the display, scalability, usability, assessment of its impact on decision-making, etc.

3.3 Application

A first overview of the fields of application shows that so far, visual analytics applications are much more focused in the field of intelligence and counter-terrorism. The research roadmap on visual analytics has been shaped by the needs post 9-11 world [TC05]. There is a need now to reinforce and steer the research agenda on visual analytics in support of better public decision making. Visual analytics would empower decision makers and analysts to make better sense of the overwhelming amount of data needed to monitor complex socio-economic phenomena.

In addition, there is a specificity in public decision making that is not sufficiently addressed within the visual

analytics discussion. If we go back to the visual representation of the three bubbles, so far the agenda on visual analytics has been mainly pursuing the goal of more timely and more evidence based decision-making. However, visual analytics could play a key role in ensuring that public decisions are widely shared and discussed: visual tools enable a wider set of constituents to take part in the discussion. It enables more informed discussion that are able to reach out further.

3.4 Research Challenges

Based on a wide literature review, the emergent challenges for Visual Analytics applied to Governance and Policy Modelling appear as:

- Turning the public information overload into an opportunity by enabling decision-makers to visually navigate through this information stream, to gain insight into the opinions expressed and to take effective actions in real-time situations.
- Presenting and aggregating visualizations into visual mash-ups in order to stimulate discussions and ground debate about policy and generally public issues on top of diagrams in ubiquitous platforms.
- Enhancing the collaboration capabilities of visualization techniques in order to allow for real-time sharing and interaction between users regardless of their location.
- Reconsidering visualization ways that will bridge the gap between the research community's offerings and the prospective users' needs in Governance and Policy Modelling.

4. Conclusions

Visual Analytics is a relatively young research field, which utilizes results from established areas such as information visualisation and data mining and has seen unprecedented growth in its first 5 years of mainstream existence. Great progress has been made in a short time, yet significant research challenges must be met in the next decade to provide new technologies that will be widely accepted throughout the world [KMT09].

In his context, in order to drive the agenda of visual analytics in public decision making forward, we need to clarify a series of open questions:

- How can visual analytics effectively integrate with other relevant research fields, such as agent-based modelling, internet of things, mass collaboration?
- What are the most advanced applications of visual analytics in the area of Governance and Policy Modelling?

The authors do not have the answer to these question at these stage. These answers can only be found through the interaction between the visual analytics community and the parallel research fields on ICT for Governance and Policy Modelling. The CROSSROAD project aims to become one platform for such a discussion.

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