Pontifícia Universidade Católica
do Rio de Janeiro

Guilherme Gonçalves Schardong

Visual interactive support for selecting scenarios from time-series ensembles

Tese de Doutorado

Thesis presented to the Programa de Pós–graduação em Informática of PUC-Rio in partial fulfillment of the requirements for the degree of Doutor em Ciências – Informática.

Advisor : Prof. Hélio Côrtes Vieira Lopes
Co-advisor: Profª. Simone Diniz Junqueira Barbosa

Rio de Janeiro
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Abstract

Schardong, Guilherme Gonçalves; Lopes, Hélio Côrtes Vieira (Advisor); Barbosa, Simone Diniz Junqueira (Co-Advisor). **Visual interactive support for selecting scenarios from time-series ensembles**. Rio de Janeiro, 2018. 17p. Tese de doutorado – Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

Stochastic programming and scenario reduction approaches have become invaluable in the analysis and behavior prediction of dynamic systems. However, such techniques often fail to take advantage of the user's own expertise about the problem domain. This work provides visual interactive support to assist users in solving the scenario reduction problem with time-series data. We employ a series of time-based visualization techniques linked together to perform the task. By adapting a multidimensional projection algorithm to handle temporal data, we can graphically present the evolution of the ensemble. We also propose to use cumulative bump charts to visually compare the ranks of distances between the ensemble time series and a baseline series. To evaluate our approach, we developed a prototype application and conducted observation studies with volunteer users of varying backgrounds and levels of expertise. Our results indicate that a graphical approach to scenario reduction may result in a good subset of scenarios and provides a valuable tool for data exploration in this context. The users liked the interaction mechanisms provided and judged the task to be easy to perform with the tools we have developed. We tested the proposed approach against state-of-the-art techniques proposed in the literature and used in the industry and obtained good results, thus indicating that our approach is viable in a real-world scenario.

Keywords

Scenario Reduction; User Interaction; Scientific Visualization; Decision Making; Time Series Ensembles.

Resumo

Schardong, Guilherme Gonçalves; Lopes, Hélio Côrtes Vieira; Barbosa, Simone Diniz Junqueira. **Uma Abordagem Visual e Interativa para a Seleção de Conjuntos de Cenários Temporais**. Rio de Janeiro, 2018. 17p. Tese de Doutorado – Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

O uso de abordagens de programação estocástica e redução de cenários tem se tornado imprescindível na análise e predição de comportamento de sistemas dinâmicos. Entretanto, tais técnicas não levam em conta o conhecimento prévio sobre domínio que o usuário possui. O presente trabalho tem por objetivo o desenvolvimento de uma abordagem visual e interativa para abordar o problema de redução de cenários com dados temporais. Para tanto, nós propomos a implementação de uma série de visualizações de dados temporais integradas. Também propomos a adaptação de um algoritmo de projeção multidimensional para lidar com dados temporais. Desta forma, podemos representar graficamente a evolução de um conjunto de cenários ao longo do tempo. Outra visualização proposta no presente trabalho é uma adaptação de *Bump chart* para lidar com dados temporais acumulados; através dele, um usuário pode comparar a evolução das distâncias entre os diferentes cenários e um cenário de referência. Para validar a nossa proposta, fizemos uma implementação das técnicas propostas e conduzimos um estudo com usuários de diferentes áreas do conhecimento e níveis de experiência. Os resultados obtidos até então indicam que uma abordagem visual para o problema de redução de cenários é viável, e permite a seleção de um conjunto razoável de cenários. Além disso, constatamos que essa abordagem pode ser útil em um contexto de exploração de dados visando a redução de cenários. O usuário também pode explorar visualmente os resultados de outras técnicas de redução de cenários usando nossa abordagem. Os usuários entrevistados reportaram facilidade em cumprir as tarefas propostas e comentaram positivamente sobre os mecanismos de interação fornecidos pelo nosso protótipo. Também testamos os cenários escolhidos usando nossa proposta contra outras abordagens encontradas tanto na literatura quanto em uso na indústria. Os resultados obtidos foram bons, indicando que nossa proposta é viável em casos de uso reais.

Palavras-chave

Redução de Cenários; Interatividade; Visualização Científica; Tomada de Decisão; Conjuntos de Dados Temporais.

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ALL THINGS THAT ARE, ARE OURS. BUT WE MUST CARE. FOR IF WE DO NOT CARE, WE DO NOT EXIST. IF WE DO NOT EXIST, THEN THERE IS NOTHING BUT BLIND OBLIVION. AND EVEN OBLIVION MUST END SOMEDAY. LORD, WILL YOU GRANT ME JUST A LITTLE TIME? FOR THE PROPER BALANCE OF THINGS. TO RETURN WHAT WAS GIVEN. FOR THE SAKE OF PRISONERS AND THE FLIGHT OF BIRDS.
LORD, WHAT CAN THE HARVEST HOPE FOR, IF NOT FOR THE CARE OF THE REAPER MAN?

Terry Pratchett, *Reaper Man.*

1
Introduction

This is a simple, introductory text demonstrating how to use the PUC-Rio's thesis/dissertations LaTeX class. Here are some citations (Lee2010), (Hummel2013), (Dupacova2003). In text citations, according to (Armstrong2013) work the same way.

In summary, the contributions of this class are:

– A more up-to-date LaTeX template for thesis/dissertations for the academic community of PUC-Rio's;

– A way to centralize changes and increase the reach of fixes and adjustments.

Table 1.1 and Figure 1.1 present ways to include tables and figures in the text. Figure 1.2 shows how to include subfigures. Section 1.1 is just a dummy section.

1.1
Thesis Structure

1.1.1 Example subsection

Table 1.1: Scenarios and errors ($\times 10^{10}$) for the industry standard approach.

Property	Percentile	Scenario	SSE	MSE
N_p	P_{10}	172	1190.0	30.5
		88	663.0	17.0
		122	1660.0	42.6
		36	**312.0**	**7.9**
	P_{50}	131	162.0	4.1
		4	**162.0**	**4.1**
		26	786.0	20.1
		90	236.0	6.0
	P_{90}	96	975.0	25.0
		100	690.0	17.7
		127	925.0	23.7
		132	**526.0**	**13.5**
W_p	P_{10}	**23**	**7640.0**	**196.0**
		115	42000.0	1080.0
		10	26900.0	690.0
		19	27600.0	707.0
	P_{50}	29	14200.0	364.0
		153	6260.0	161.0
		84	**5840.0**	**150.0**
		88	11200.0	288.0
	P_{90}	37	14300.0	367.0
		57	22300.0	571.0
		187	14000.0	358.0
		28	**2210.0**	**56.7**

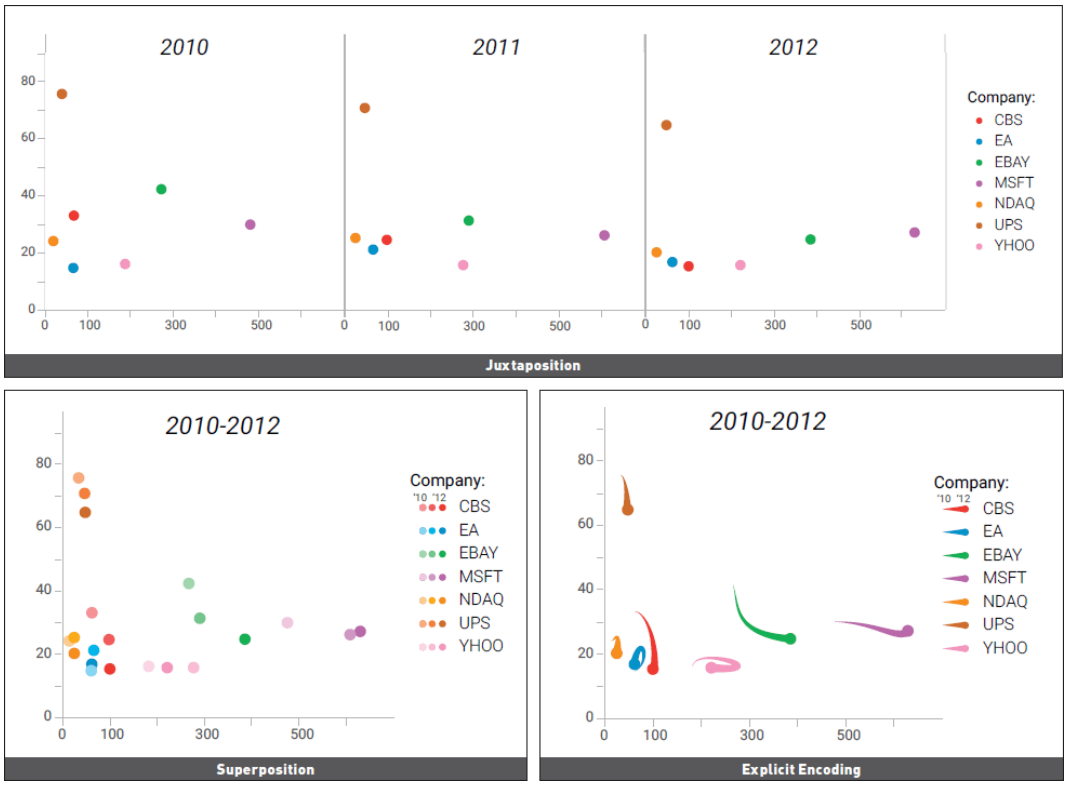
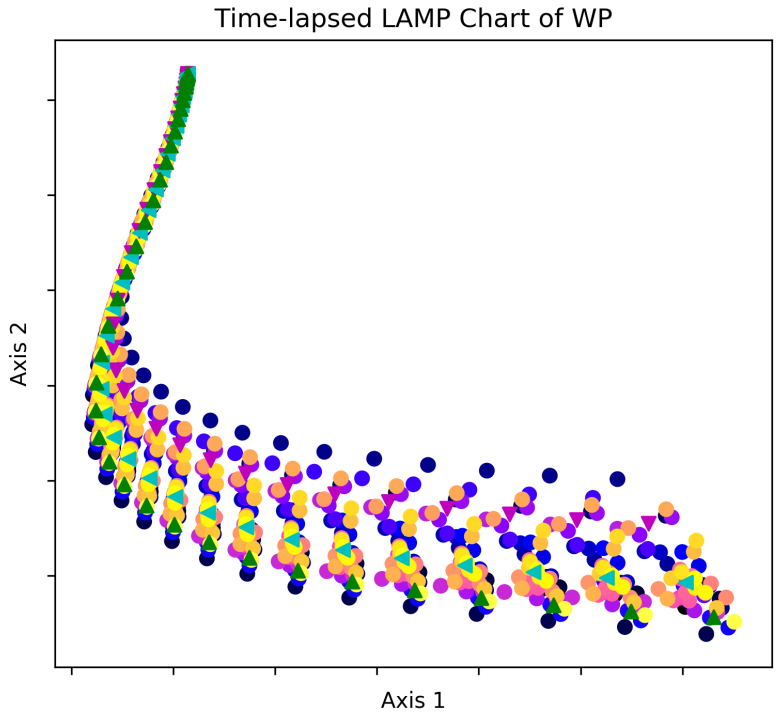
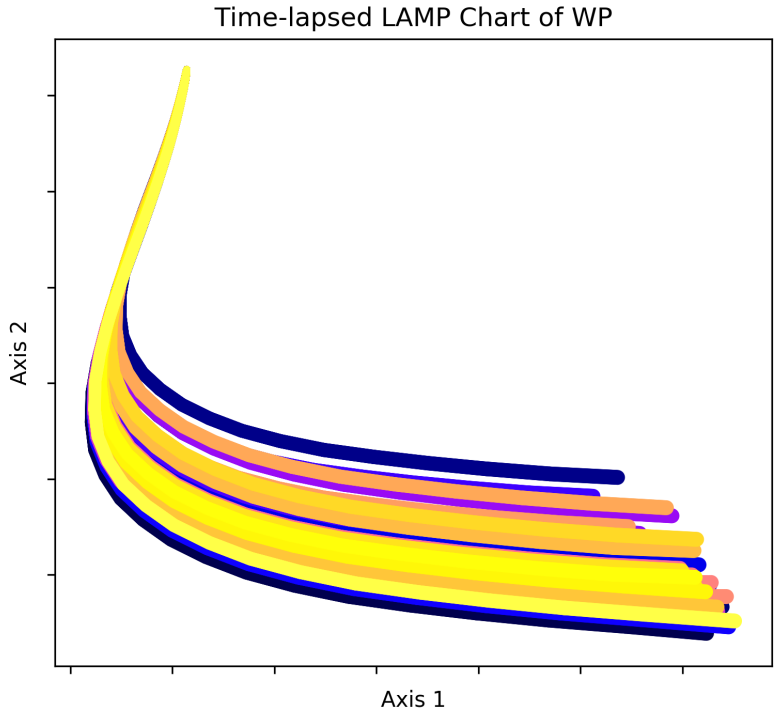


Figure 1.1: Juxtaposition, Superposition and Explicit Encoding. Image taken from the work of (Szafir2018).



(a) Superposition of times in the Time-lapsed LAMP chart.



(b) Explicit encoding of time in the Time-lapsed LAMP chart. Starting times encoded with smaller glyphs.

Figure 1.2: Comparison between different time encodings on the Time-lapsed LAMP chart of W_p. Superposition (1.2a) and Explicit Encoding (1.2b) from small to large glyphs.

1.1.2 Sample theorems, lemmas and proofs

Theorem 1.1 *Let f be a function whose derivative exists in every point, then f is a continuous function.*

Theorem 1.2 (Pythagorean theorem) *This is a theorema about right triangles and can be summarised in the next equation*

$$x^2 + y^2 = z^2$$

And a consequence of theorem 1.2 is the statement in the next corollary.

Corollary 1.3 *There's no right rectangle whose sides measure 3cm, 4cm, and 6cm.*

Lemma 1.4 (Unimodularity preserving matrix operations) *The following matrix operations, called unimodular operations, preserve the unimodularity property from an already unimodular matrix:*

1. *Interchange two columns*
2. *Add an integer multiple of a column to another column*
3. *Multiply a column by -1*
4. *Transpose*

Lemma 1.5 *Given two line segments whose lengths are a and b respectively there is a real number r such that $b = ra$.*

Proof. To prove Lemma 1.5 by contradiction try and assume that the statemenet is false, proceed from there and at some point you will arrive to a contradiction. ■

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A
User profile questionnaire for prototype evaluation sessions

1. Personal information

   (a) Name

   _____

   (b) E-mail

   _____

   (c) Education degree

   _____

   (d) Course semester (just for students)

   _____

   (e) Occupation

   _____

2. Please mark below your knowledge about the following subjects:

   (a) Division of a sample by percentiles: P10, P50, P80 ...

   ◯ I do not know

   ◯ I know little (I have learned these concepts at some point, but may have to learn again if I have to apply them)

   ◯ I have average knowledge (I may have to revise one concept or another if I have to apply it)

   ◯ I know well (I do not apply often, but I would not need to revise the concepts if I had to apply them)

   ◯ I am a specialist (I apply these concepts frequently)

   (b) Analysis of trends and patterns in time series

   ◯ I do not know

   ◯ I know little (I have learned these concepts at some point, but may have to learn again if I have to apply them)

   ◯ I have average knowledge (I may have to revise one concept or another if I have to apply it)