Visual Comparison of Business Process Flowcharts

Bernhard Häussner

Julius-Maximilians-Universität Würzburg
Institut für Informatik
Lehrstuhl für Informatik I
Algorithmen, Komplexität und wissensbasierte Systeme

Advisors:
Prof. Dr. Alexander Wolff
Fabian Lipp, M. Sc.

2018-03-18
What are Business Process Flowcharts?

Example for an event-driven process chain (EPC) as described by W. M. P. van der Aalst 1999. The process of making and consuming pie.
Why? Motivation from industry needs

- Adaption of commercial off-the-shelf (COTS) software [Komplex-e]
Why? Motivation from industry needs

- Adaption of commercial off-the-shelf (COTS) software [Komplex-e]
- Workflows are documented, managed and compared as digital business process models. [de Moor and Delugach 2006]
Why? Motivation from industry needs

- Adaption of commercial off-the-shelf (COTS) software [Komplex-e]
- Workflows are documented, managed and compared as digital business process models. [de Moor and Delugach 2006]
- Merging organizational units
Automatic process model matching

- AI algorithms can give a similarity score [Dijkman et al. 2011]
Automatic process model matching

- AI algorithms can give a similarity score [Dijkman et al. 2011]
- A process model matching contest yielded various results [Antunes et al. 2015]
Automatic process model matching

- AI algorithms can give a similarity score [Dijkman et al. 2011]
- A process model matching contest yielded various results [Antunes et al. 2015]
- Results are never completely correct, making human visual comparison necessary
Business process flowcharts are graph drawings

- Business processes are basically graphs
Business process flowcharts are graph drawings

- Business processes are basically graphs
- With nodes and edges
Business process flowcharts are graph drawings

- Business processes are basically graphs
- With nodes and edges
- Use graph drawing for layouting
Sugiyama [1981] graph drawing is suitable for business process flowcharts

Five steps of layered graph drawing:

- Cycle breaking
- Layer assignment
- Vertex ordering
- Horizontal positioning
- Edge drawing
Visual graph comparisons are not easy

A graph.

The same graph?
Can we also use graph comparisons?

- Not a whole lot of literature on visual graph comparison

Biologists draw metabolic pathways, which are series of chemical reactions. [Schreiber 2003]

Merging of graphs with Semantic Graph Visualiser (SGV) [Andrews et al. 2009]

New idea: Bringing vertices to the same height
Can we also use graph comparisons?

- Not a whole lot of literature on visual graph comparison
- Biologists draw metabolic pathways, which are series of chemical reactions. [Schreiber 2003]
Can we also use graph comparisons?

- Not a whole lot of literature on visual graph comparison
- Biologists draw metabolic pathways, which are series of chemical reactions. [Schreiber 2003]
- Merging of graphs with Semantic Graph Visualiser (SGV) [Andrews et al. 2009]
Can we also use graph comparisons?

- Not a whole lot of literature on visual graph comparison
- Biologists draw metabolic pathways, which are series of chemical reactions. [Schreiber 2003]
- Merging of graphs with Semantic Graph Visualiser (SGV) [Andrews et al. 2009]
- New idea: Bringing vertices to the same height
Bringing vertices to the same height

A graph with “constraints” between similar nodes
Bringing vertices to the same height

- Inserting space between layers
Bringing vertices to the same height

- Inserting space between layers
- Problem: Crossings of constraints
Bringing vertices to the same height

- Inserting space between layers
- Problem: Crossings of constraints
- Solution: select as many non crossing constraints as possible
Bringing vertices to the same height

- Inserting space between layers
- Problem: Crossings of constraints
- Solution: select as many non crossing constraints as possible
- But how?
Bringing vertices to the same height

Two graphs with similarities
Bringing vertices to the same height

Two graphs with similarities

We only need to look at layers
Bringing vertices to the same height

We only need to look at layers
Bringing vertices to the same height

We only need to look at layers
Bringing vertices to the same height

We only need to look at layers

- We can only bring one of two crossing lines to the same level
- Line crossings form a conflict graph
- Just need to find a maximum independent set
- NP complete?
Bringing vertices to the same height

We only need to look at layers

Conflict graph
Permutation graphs

- Permutation graphs [Even et al. 1972]
- Vertices: elements of a permutation
- Edges: pairs of elements that are reversed by the permutation
- The conflict graphs are permutation graphs
Bringing vertices to the same height

The permutation reads as 3, 1, 8, 7, 4, 2, 5, 6
Finding an independent set

- (Maximum) independent sets are (longest) increasing subsequences
- Can be found in $O(n \log n)$ time
- Algorithm uses ideas from Aldous and Diaconis 1999 and Kim 1990
Example

The permutation reads as 3, 1, 8, 7, 4, 2, 5, 6

Permutation graph

Other examples:
3, 8, 7, 4, 5, 6, 1, 2
4, 2, 3, 1
The graphs adjusted according to the longest increasing subsequence

The adjusted layers
Possible improvement: interpolation

Adjusted by adding space

Adjusted by spreading to fill the space
Another variant: adjusted scrolling
Evaluation

- A tool was developed using JUNG [O’Madadhain et al. 2005] and KIELER
Evaluation

- A tool was developed using JUNG [O’Madadhain et al. 2005] and KIELER
- Includes Andrews et al.’s SGV comparison with merged graphs
Evaluation

- A tool was developed using JUNG [O’Madadhain et al. 2005] and KIELER
- Includes Andrews et al.’s SGV comparison with merged graphs
- Works on EPCs, including those from Komplex-e and the 2015 process model matching contest
Comparing the numbers

- SGV: height: -11% to +48%, on average +6%
- SGV: width: +38% to +258%, on average +128%
- Height adjustment: height: +3% to 46%, on average +22%
- Height adjustment: width: no change
Comparing the numbers

- SGV: height: -11% to +48%, on average +6%
- SGV: width: +38% to +258%, on average +128%
Comparing the numbers

- SGV: height: -11% to +48%, on average +6%
- SGV: width: +38% to +258%, on average +128%
- Height adjustment: height: +3% to 46%, on average +22%
Comparing the numbers

- SGV: height: -11% to +48%, on average +6%
- SGV: width: +38% to +258%, on average +128%
- Height adjustment: height: +3% to 46%, on average +22%
- Height adjustment: width: no change
User study

- Tested on two participants first
User study

- Tested on two participants first
- Learnings were incorporated into a final questionnaire of 42 questions
User study

- Tested on two participants first
- Learnings were incorporated into a final questionnaire of 42 questions
- Three different example processes were picked

Result: slightly more generous answers for height adjustment and adjusted scrolling vs. merged layout, but only small sample size.
User study

- Tested on two participants first
- Learnings were incorporated into a final questionnaire of 42 questions
- Three different example processes were picked
- 13 participants (8 CS, 3 Econ., 2 others)
  Result: slightly more generous answers for height adjustment and adjusted scrolling vs. merged layout, but only small sample size.
Future Work

- Smart use of colors to highlight similar elements
Future Work

▶ Smart use of colors to highlight similar elements
▶ Extension of the longest increasing subsequence algorithm to the weighted problem
Future Work

- Smart use of colors to highlight similar elements
- Extension of the longest increasing subsequence algorithm to the weighted problem
- Improvement of constraint visualisation
Future Work

- Smart use of colors to highlight similar elements
- Extension of the longest increasing subsequence algorithm to the weighted problem
- Improvement of constraint visualisation
- $n : m$ matchings