Building a clearer picture of dynamic visualisations

Dynamic visualisations can provide valuable insights into time-varying data like stock prices and traffic information, helping us to identify patterns and get a clearer overall picture of how they are likely to evolve. Dr Kevin Verbeek tells us about his work in analysing the stability of the geometric algorithms behind these visualisations.

Many people monitor traffic data on phone apps or other technologies before setting out on a journey, helping them to avoid hot-spots and get to their destination as quickly as possible. The data on traffic patterns constantly evolves, which is an important consideration in terms of presenting it to drivers in an accessible and digestible way. "If you want to take that data and turn it into a picture using an algorithm, then you need to make sure that if the data slightly changes, then the picture that you produce doesn't suddenly completely change," points out Dr Kevin Verbeek. The goal when visualising data, whether it's traffic information, stock prices, or something else entirely, is to identify patterns. "You want to figure out exactly what is happening in the data. A visual picture will give you an idea or summary of that, so you need this to be very stable," explains Dr Verbeek.

Algorithm stability

The stability of the underlying algorithms behind these visual pictures is an important factor in this respect, a topic which lies at the heart of Dr Verbeek's research. Based at the Eindhoven University of Technology, Dr Verbeek is taking a step back to look at fundamental questions around the stability of an algorithm. "The question arises of how do I measure stability? How do I analyse stability? What tools can I use to do this formally?" he outlines. In a simple sense, an algorithm takes an input and generates an output; one measure of stability involves relating the two. "If the difference in the input is small, then the difference in the output should also be small. This is the most important aspect," explains Dr Verbeek. "From a data visualization point of view, it would be even better if the difference in output corresponded directly to the difference in input."

There are also trade-offs to be made in terms of the specific characteristics of an algorithm. While it might seem desirable for an algorithm to find the optimal solution for a particular problem, this may have an impact on its stability. "The interesting thing is that if you always want to find the optimal solution – which in some cases we can, although it's hard – then this optimal solution might be very unstable. We often find that there is a trade-off between how good your solution can be, and how stable the algorithm is," says Dr Verbeek. With a little bit more leeway with respect to the nature of the solution, it's then possible to make an algorithm more stable. "The optimum solution is very fixed, it's a small point. If you give yourself a little more room in terms of the output that you're producing, then you can use that room to become more stable," explains Dr Verbeek.

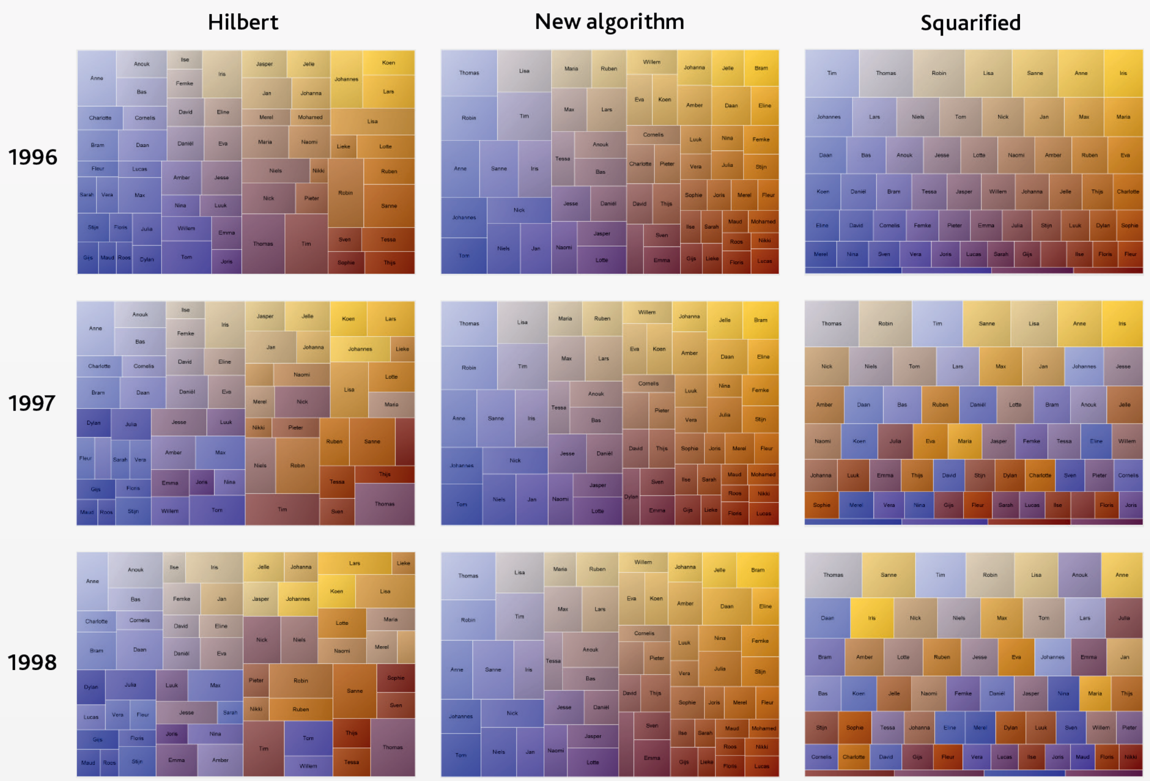
A key objective in this research is to develop new analysis techniques to assess the stability of algorithms, while Dr Verbeek also intends to apply them and see if they actually work in practice. While this is not an entirely new area of investigation, researchers are yet to develop a reliable theory on how to deal with the nature of stable algorithms. "That is one of the main goals of this project – to define what kinds of analysis can be used and what kinds of tools are useful," says Dr Verbeek. These tools could in principle be applied to any kind of algorithm, although Dr Verbeek acknowledges that they may be more applicable to some than others. "Usually the most interesting types of algorithms in terms of our research are those where your input is essentially continuous. In that way you can map it to something that takes place over time," he says.

The stability of the underlying algorithm has a practical impact on visualisation, yet currently there is no rigorous theory to debate these problems and provide a framework for further research. By developing the theoretical foundations behind this essentially practical problem, Dr Verbeek hopes to lay the groundwork for further research in future. "The goal of the project is to actually ignite a level of interest in these theoretical problems relating to the stability of algorithms. When you have theoretical knowledge about a particular problem, you build an understanding that you can then use in practice," he explains. This can lead to new insights and spur continued research. "We've been writing papers describing how we use these techniques, and aiming to show that they can lead to interesting insights," outlines Dr Verbeek.

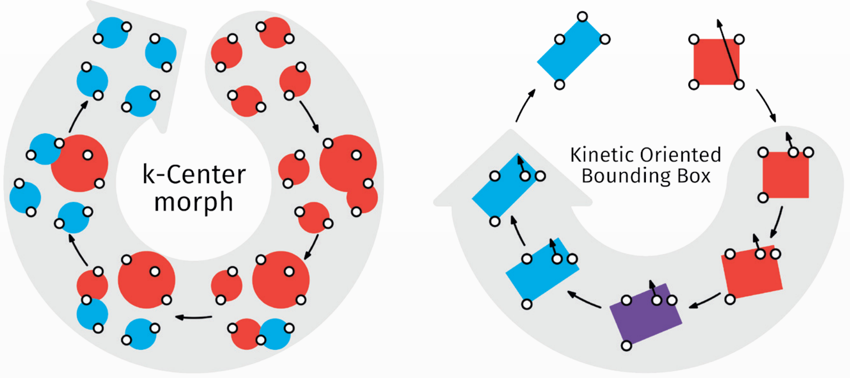
This is partly about encouraging theoretical and practical researchers to work in close collaboration, which in practice is very difficult however. Not only do they almost speak different languages in a sense, but there are also other challenges to overcome. "I usually try to work on the intersection between theoretical and practical research, so I write theoretical papers and I write practical papers. But there has been a reluctance to accept these kinds of papers – where if you work on the intersection and you write a theory paper, then somehow the theoretical aspects are considered to not be deep enough, because you based it on a real practical problem," says Dr Verbeek. "On the other hand, if you write a practical paper that uses such theory to solve a practical problem, then the methods are often not well understood and are considered to be too complicated."

Knowledge transfer

Knowledge transfer is therefore a challenge, but it's also something that inspires Dr Verbeek's work and will remain a central consideration. While the project itself will conclude relatively soon, investigations into both the theoretical and practical issues around the stability of algorithms is ongoing, and Dr Verbeek hopes to help build and strengthen the research community. "I would like some of these things to be taken up the research community, in particular seeing other people using these techniques and tools to prove certain things about their algorithms," he outlines. Dr Verbeek also plans to attend conferences and publish papers, which will help generate interest. "The idea is to get this to as many conferences and workshops as we can, where we can present our work and push these ideas," he says. "The interaction between theoretical and practical issues is important, as that's where the problem lies. There's really an interaction between the two."



The new treemapping algorithm developed by Dr. Verbeek and his collaborators is much stabler than existing algorithms (Hilbert and squarified), whilst at the same time keeping the quality of the visualization high over all time steps.



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STABLE GEOMETRIC ALGORITHMS

Less confusion from dynamic information

Project Objectives

An algorithm is stable if small changes in the input lead to small changes in the output. Stable algorithms play an important role in, for example, the visualization of time-varying data. The main goals of this project are to develop a new theoretical framework for algorithm stability, introduce new methodologies to analyze algorithm stability, and to develop new stable (geometric) algorithms.

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Project Partners

- Prof. dr. Bettina Speckmann
- Dr Wouter Meulemans
- ir. Jules Wulms
- ir. Max Sondag

Contact Details

Project Coordinator,
Dr Kevin Verbeek
Mathematics and Computer Science
TU Eindhoven, MF 4.106
P.O. Box 513
5600 MB Eindhoven
T: +31 40 247 8926
E: k.a.b.verbeek@tue.nl
W: https://www.win.tue.nl/~kverbeek
W: https://www.win.tue.nl/aga/

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Dr Kevin Verbeek

Dr Kevin Verbeek is an assistant professor in the Applied Geometric Algorithms group at TU Eindhoven. His main research interests lie within the area of computational geometry. Kevin is specialized in using theoretical techniques from computational geometry to solve real-world problems, mostly in the area of information visualization.

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