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Image-Based Information Visualization Techniques

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Abstract

While many data exploration techniques are based on automatic knowledge extraction, other tools exist where the user plays the central role. This presentation will report actual use-cases where the user interactively explores datasets and extracts relevant information. These techniques must be interactive enough to insure flexibility data exploration, therefore image-based algorithms propose a suitable solution. These algorithms, processed in parallel by the graphic card, are fast and scalable enough to support interactive big data exploration requirements.

CCS Concepts

•***Human-centered computing*** → ***Human computer interaction (HCI); Interaction techniques; Interactive systems and tools;***

1. Introduction

Our society has entered a data-driven era, in which not only enormous amounts of data are being generated every day, but also growing expectations are placed on their analysis [TC05]. Analyzing these massive and complex datasets is essential for making new discoveries and creating benefits for people, but this remains a difficult task; most data have become simply too large to be displayed and often have too short lifespan, i.e. they change too rapidly for a classical visualization or analysis methods to handle them. This is particularly important for movement data, such as traffic data on roads or in airspace, because of their intrinsic time-dependent nature. Machine learning with distributed systems heralds the solution to address the big data issues and efficient knowledge extraction. Nevertheless, alternatives do exist where humans play a central role with the usage of interactive visualization systems [HK12]. With regards to this data deluge, what remains relatively constant is our own cognitive ability to make sense of the data and take reliable and informed decisions. Information Visualization (InfoVis) is defined as 'the use of computer-supported, interactive, visual representations of abstract data to amplify cognition' [CMS99]. InfoVis provides the scientific support to leverage user analytical capabilities with interactive visualization.

The presentation relies on a new generation of high-performance visualization paradigms, such as Image-Based visualizations (fast parallel GPU computation) to gain new insights from multidimensional data sets. The graphic card is not only used to display information but also to support interaction [Hur15]. This data exploration paradigm is at the crossroads of Information Visualization, Visual Analytics, Computer Graphics and Human-Computer Interaction.

As scientific challenges, image based techniques try to answer the following questions. How to depict large data (data visualization), how to do so in an efficient way? How to interact efficiently with large data sets, and how to do it in a way that fosters discoveries?

Figure 1: *Mixed reality data visualization and manipulation.*

As Technical challenges, Image-Based techniques focus on algorithms working in the graphic space (Pixel-Based). This consists of two steps: first, a data representation is built using existing visualization and interaction techniques; then the resulting image undergoes only graphical transformations using image processing techniques, mostly performed by the graphic card so called GPGPU techniques (General-Purpose computing on Graphics Processing Units) [OLG*] . These techniques will be applied at every stage of the data processing pipeline: data collection, cleaning, wrangling, sorting, exploring, knowledge extraction. This presentation will depict this innovative approach with Image/Pixel-Based Techniques.

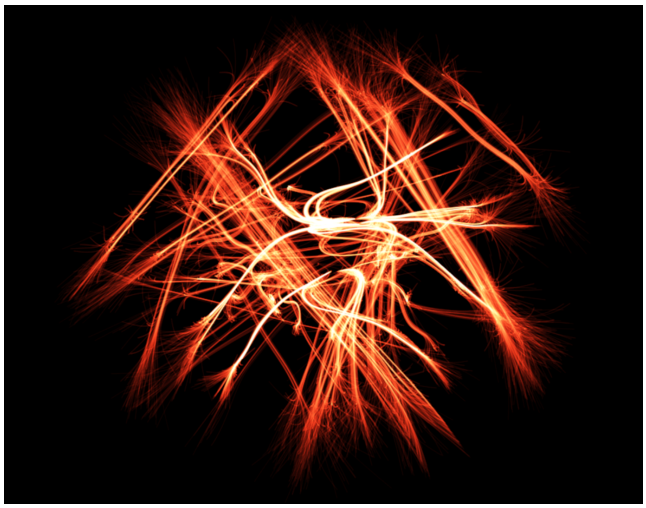

Figure 2: *This image shows air traffic visualization with edge bundling simplification technique [HPNT18].*

2. Presentation outlines

Every section will be illustrated with numerous demos and videos to make the presentation as concrete and as practical as possible.

2.1. Introduction of Image-Based techniques

The Image-Based approach takes advantage of changes in the bottlenecks of computer graphics: since data storage and memory limitation is becoming less and less of an issue [Sut12], we can plan to reduce computation time by using memory as a new tool to solve computationally challenging problems. Furthermore, even if graphic cards were initially developed to produce 2D/3D views close to photo-realistic images, their power has also been used to perform parallel computations (so called GPGPU techniques). Principle of this new data exploration principle was introduced by McDonnel et al. [ME09] and further extended by Hurter [Hur15].

2.2. Part II : focus on Image-Based visualization techniques to address scalability issues

This part of the presentation will mostly focus on clutter removal in dense visualizations. Many improvement have been recently done with visual aggregation techniques also called edge bundling [LHT17]. While these techniques mostly apply on graph or trail sets, they open interesting opportunities to gain a better understanding of dense and complex visualizations.

2.3. Part III : focus on interactive Image-Based technique to address scalability issues

During this presentation, we will investigate how to build a system with low latency to foster big data exploration. GPU usage and astute memory management with Image-Based techniques will address these latency issues (e.g. response time to a query). As such, Image-Based techniques will go beyond the interactive data exploration paradigm [HTT09] by investigating the association of interactions and visualizations to support direct manipulation of datasets [Shn83].

2.4. Part IV : Application domain examples

During this presentation, we will present a review of exiting Image-Based interactive visualization techniques and algorithms with concrete application domain use-cases. We will show and explain how to interactively explore large dataset (one day of recorded aircraft trajectories [HTC09] (figure 2), 3D scan [HTCT14], dimension reduction [KHS*17]) and show how to interactively extract knowledge and support decision making thanks to interactive techniques (multidimensional data exploration, visual simplification, data filtering). Eye tracking data [Duc02] and their analyses [BKR*14] are gaining recent interests and Image-Based technique showed promising opportunities [PHT15]. We will also demonstrate advance visualization techniques with the HoloLens device figure 1) and immersive headsets [HM17].

2.5. Part V : Conclusion and Research perspectives

This section will conclude the presentation with an open discussion of future research direction and opportunities for Image-Based algorithms.

Bio: Christophe Hurter is professor at the Interactive Data Visualization group (part of the DEVI team) of the French Civil Aviation University (ENAC) in Toulouse, France. He is also an associate researcher at the research center for the French Military Air Force Test Center (CReA). In 2010, he received his PhD in Computer Science from the Toulouse university and in 2014 he got his HDR (Habilitation a Diriger des Recherche). His research covers information visualization (InfoVis) and human-computer interaction (HCI), especially the visualization of multivariate data in space and time. He also investigate the design of scalable visual interfaces and the development of pixel/image-based rendering techniques. Throughout his career he have been involved with several projects including: large data exploration tools, graph simplifications (edge bundling), paper based interactions, augmented reality, 3D visualization...

References

[BKR*14] BLASCHECK T., KURZHALS K., RASCHKE M., BURCH M., WEISKOPF D., ERTL T.: State-of-the-art of visualization for eye tracking data. In *Proceedings of EuroVis* (2014), vol. 2014. 2

[CMS99] CARD S. K., MACKINLAY J. D., SHNEIDERMAN B. (Eds.): *Readings in Information Visualization: Using Vision to Think*. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 1999. 1

[Duc02] DUCHOWSKI A. T.: A breadth-first survey of eye-tracking applications. *Behavior Research Methods, Instruments, & Computers 34*, 4 (2002), 455–470. 2

[HK12] HEER J., KANDEL S.: Interactive analysis of big data. *XRDS 19*, 1 (Sept. 2012), 50–54. URL: http://doi.acm.org/10.1145/2331042.2331058, doi:10.1145/2331042.2331058. 1

[HM17] HURTER C., MCDUFF D.: Cardiolens: Remote physiological monitoring in a mixed reality environment. In *ACM SIGGRAPH 2017 Emerging Technologies* (New York, NY, USA, 2017), SIGGRAPH '17, ACM, pp. 6:1–6:2. URL: http://doi.acm.org/10.1145/3084822.3084834, doi:10.1145/3084822.3084834. 2

[HPNT18] HURTER C., PUECHMOREL S., NICOL F., TELEA A.: Functional decomposition for bundled simplification of trail sets. *IEEE Transactions on Visualization and Computer Graphics 24*, 1 (Jan 2018), 500–510. doi:10.1109/TVCG.2017.2744338. 2

[HTC09] HURTER C., TISSOIRES B., CONVERSY S.: Fromdady: Spreading aircraft trajectories across views to support iterative queries. *IEEE TVCG 15*, 6 (Nov. 2009), 1017–1024. URL: http://dx.doi.org/10.1109/TVCG.2009.145, doi:10.1109/TVCG.2009.145. 2

[HTCT14] HURTER C., TAYLOR R., CARPENDALE S., TELEA A.: Color tunneling: Interactive exploration and selection in volumetric datasets. *2014 IEEE Pacific Visualization Symposium (PacificVis) 00* (2014), 225–232. doi:doi.ieeecomputersociety.org/10.1109/PacificVis.2014.61. 2

[HTT09] HEY T., TANSLEY S., TOLLE K. (Eds.): *The Fourth Paradigm: Data-Intensive Scientific Discovery*. Microsoft Research, Redmond, Washington, 2009. URL: http://research.microsoft.com/en-us/collaboration/fourthparadigm/. 2

[Hur15] HURTER C.: Image-based visualization: Interactive multidimensional data exploration. *Synthesis Lectures on Visualization 3*, 2 (2015), 1–127. 1, 2

[KHS*17] KRUIGER J. F., HASSOUMI A., SCHULZ H.-J., TELEA A., HURTER C.: Multidimensional data exploration by explicitly controlled animation. *Informatics 4* (2017), 26. 2

[LHT17] LHUILLIER A., HURTER C., TELEA A.: State of the art in edge and trail bundling techniques. *Comput. Graph. Forum 36*, 3 (June 2017), 619–645. URL: https://doi.org/10.1111/cgf.13213, doi:10.1111/cgf.13213. 2

[ME09] MCDONNEL B., ELMQVIST N.: Towards utilizing gpus in information visualization: A model and implementation of image-space operations. *IEEE Transactions on Visualization and Computer Graphics 15*, 6 (Nov 2009), 1105–1112. doi:10.1109/TVCG.2009.191. 2

[OLG*] OWENS J. D., LUEBKE D., GOVINDARAJU N., HARRIS M., KRÃIJGER J., LEFOHN A. E., PURCELL T. J.: A survey of generalâĂŘpurpose computation on graphics hardware. *Computer Graphics Forum 26*, 1, 80–113. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-8659.2007.01012.x, arXiv:https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-8659.2007.01012.x, doi:10.1111/j.1467-8659.2007.01012.x. 1

[PHT15] PEYSAKHOVICH V., HURTER C., TELEA A.: Attribute-driven edge bundling for general graphs with applications in trail analysis. In *Visualization Symposium, 2015 IEEE Pacific* (2015), IEEE, pp. 39–46. 2

[Shn83] SHNEIDERMAN B.: Direct manipulation: A step beyond programming languages. *Computer 16*, 8 (Aug. 1983), 57–69. URL: http://dx.doi.org/10.1109/MC.1983.1654471, doi:10.1109/MC.1983.1654471. 2

[Sut12] SUTHERLAND I.: The tyranny of the clock. *Commun. ACM 55*, 10 (Oct. 2012), 35–36. URL: http://doi.acm.org/10.1145/2347736.2347749, doi:10.1145/2347736.2347749. 2

[TC05] THOMAS J. J., COOK K. A.: *Illuminating the Path: The Research and Development Agenda for Visual Analytics*. National Visualization and Analytics Ctr, 2005. URL: http://www.amazon.com/exec/obidos/redirect?tag=citeulike07-20&path=ASIN/0769523234. 1