The desktop is dead, long live the desktop!

Towards a multisensory desktop for visualization

Jonathan C.Roberts* Joseph W. Mearman† Panagiotis D.Ritsos‡
Bangor University Bangor University Bangor University

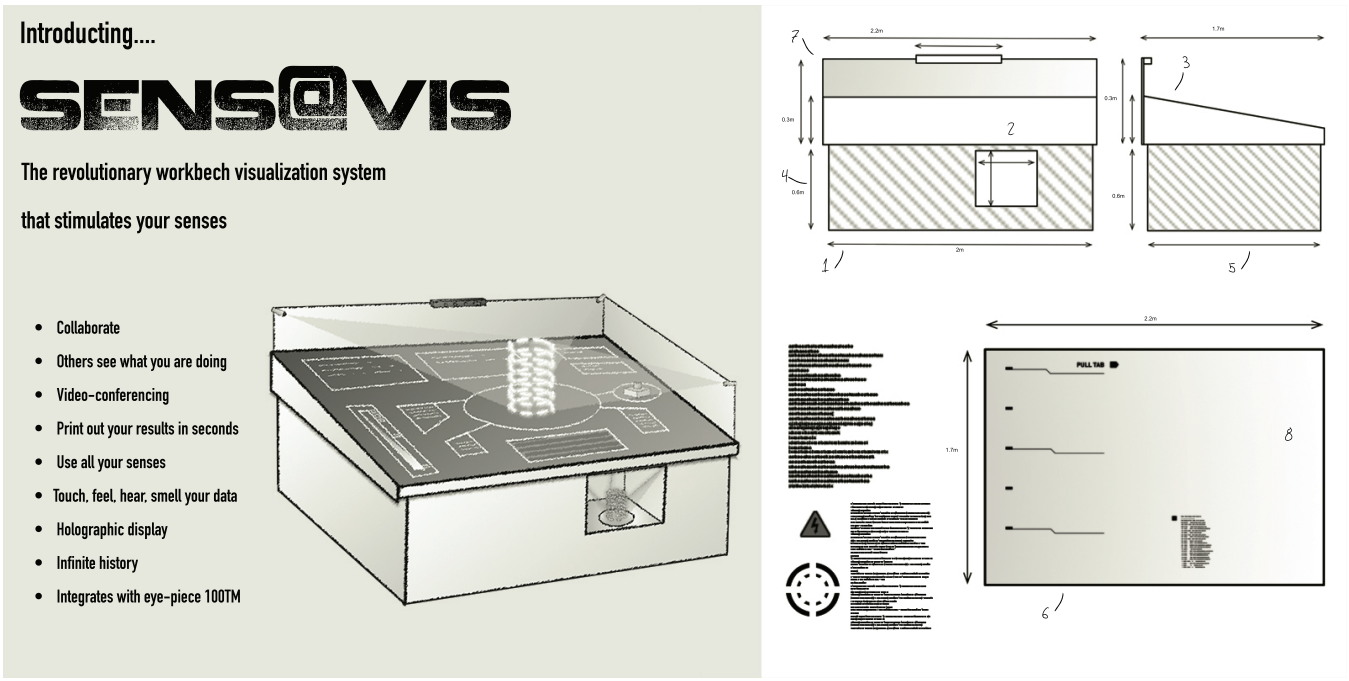

Figure 1: While we acknowledge the desktop as we know it is dead, we still believe that in the future there will be need for a personal workspace that would utilize all our senses. This post-WIMP interface would be a multi-sensory personal desktop space; collabative; integrate **all** senses; enable holograms to be touched and manipulated in 3D; and even rapid-print final 3D visualization designs and solutions.

ABSTRACT

"Le roi est mort, vive le roi!"; or "The King is dead, long live the King" was a phrase originally used for the French throne of Charles VII in 1422, upon the death of his father Charles VI. To stave civil unrest the governing figures wanted perpetuation of the monarchs. Likewise, while the desktop as-we-know-it is dead (the use of the WIMP interface is becoming obsolete in visualization) it is being superseded by a new type of *desktop* environment: a multisensory visualization space.

This *space* is still a personal workspace, it's just a new kind of desk environment. Our vision is that data visualization will become more multisensory, integrating and demanding all our senses (sight, touch, audible, taste, smell etc.), to both manipulate and perceive the underlying data and information.

Keywords: Multi-sensory visualization; haptic data visualization; Interaction Techniques

Index Terms: Information Interfaces and Presentation [H.5.2]: User Interfaces—Graphical User interfaces (GUI)

*e-mail: j.c.roberts@bangor.ac.uk
†e-mail: j.w.mearman@bangor.ac.uk
‡e-mail: p.ritsos@bangor.ac.uk

1 INTRODUCTION

Visualization need not solely be 'visual'. Different senses can be utilized to perceive (as well as manipulate) data [8]. Researchers are starting to investigate many non-visual (multisensory) information visualization techniques, and are incorporating different sensory modalities (sight, touch, audible, taste, smell etc) in their information visualization interfaces. We need to move beyond the desktop environment [7], and look to other forms of sensations.

We are certainly living at a time, where new interface technologies are rapidly being developed; costs of these technologies are dropping; they are getting smaller, always switched on, always with us and becoming more integrated with our human being. This is a huge time of change. Over the next five, ten, fifteen years this interface and display device revolution will only gain pace. These technologies are already today enabling users to touch and manipulate data through (say) touch-display interfaces.

In the future we will be living in a world where technologies integrate more closely with our human nature. Consequently, and likewise, our visualization tools will need to be more closely entwined with our human senses.

Our vision is twofold:

1. **That we will need a personal workspace for visualization.** This will enable users to manipulate data and explore different scenarios or hypotheses, regarding their data, and collaborate with others remotely.
2. **It will be a multi-sensory experience**, where users can touch, feel and interact with their data in a more 'humanistic' way through direct sensory manipulation and verbal commands.

Therefore we need to explore how we can integrate different senses into our visualization experiences. Not just the sense of sight and touch but to sound, smell or even taste. For instance, we could virtually pick-up a group of points in a 3D scatterplot, estimate the quantity of points in the group by feeling the weight of the points, move it to one side and hear a sonification of the data depicting the distribution of the values.

We feel that as a community, we should put more effort and emphasis into researching how different sensory capabilities can be integrated into our visualization tools, such to attain our vision, and to keep pace with the current technological revolution.

The purpose of this paper is threefold. First we wish to motivate the community to think 'multi-sensory'; second to broaden opinions and perceptions over visualization to include a wider range of human senses in our data visualization experiences; and third to start to explore a draft agenda, or areas of research that should be achieved, in order to achieve our vision of a multi-sensory visualization workspace.

Figure 2: 3D interactive table, using a Kinect [1].

2 Current Trends

We are to some extent already performing multimodal (multisensory) human-computer interaction, and also specifically multimodal visualization interaction; this is because we already use a mouse (a tactile interface that uses the human ability to move its muscles and for the human to judge where his/her hand is) along with display technologies (through sight). Other human-computer interfaces also use sound along with sight. For instance, operating systems often play sounds to provide feedback to the user: such to denote when a button has been pressed, or when an event has occurred (e.g., the completion of some processing task).

Nowadays tablet PCs seamlessly blend touch with display; mobile phones vibrate and play a tune with an incoming call; while, car manufacturers include sensors and cameras to evaluate nearby objects which are represented by different sounds at variable pitches, and sometimes the video feed is annotated through a head-up-display with the actual distance measure. Again staying with car manufacturers, they are already integrating vibrotactile actuators in the seats, which vibrate when the vehicle goes over a lane marker, such to help drivers keep inside a particular lane. Again vibration is used to denote a received text message on a smart-phone when in a meeting.

However, we wish to go further, not only to denote a single value (a notification of a single event) in a non-visual modality, but to realize several values. Thus to create a full multimodal visualization experience. For example, a scalar value that would be traditionally displayed in a color, could be mapped to a pitch, or a vibration (in a vibrotactile display), or the piquantness of a smell.

For visualization tools specifically, we are starting to see different modalities being integrated: rapid three-dimensional printing has been used to print objects that can be manipulated by users. These tangible objects can also be used along with other display technologies, and as such the tangible objects become an interface in their own right.

In other work tactile table-top displays are starting to be used for collaborative visualization discovery, where several users can simultaneously manipulate and explore the visual representations. Researchers have already started to create 3D displays (see Figure 2) and use haptic devices to display data [5, 6].

3 New multisensory display technologies

While some of these concepts and current technologies alone are not new (such as exemplified by Morton Heilig 1950's "Sensorama", incorporating moving images, sound and smell), the size, cost, fidelity, power etc. of these new devices bring forward the vision of the personal visualization workspace.

This rapid technological growth is enabling these *visions* to become reality: they are ubiquitous and far reaching into every aspect of life. This ubiquity is readily exemplified by the inclusion and use of vibrotactile actuators in our every day life. Their inclusion in mobile devices and on games consoles (e.g., the Wiimote) not only bring feedback to touch interfaces, but offer additional communication bandwidth for information visualization and can provide novel interaction paradigms.

In fact, just focusing on haptics, the more complex force-feedback devices such as Sensables Phantoms or Omnis, Haptic Master, CyberGlove and similar devices are moving out of research labs, reducing in cost and becoming more available for the general public. The Novint Falcon, is one such example, and provides a force-feedback device that starts at $249.

There are several recent innovations that could be significant step-changes for multi-sensory visualization purposes. For instance:

1. high quality, positional sound systems are falling in cost and becoming available such to better sonification;
2. Surface haptic devices (such as ShiverPad [2]) by Ed Colgate and colleagues are being furthered by Microsoft research for potential inclusion in touch tablets.
3. Non-contact (airborne) haptics are being developed using ultrasound transducers to generate 3d tactile sensations [3].
4. FabLabs enable fast and cheap creation of tangible objects that can be used in visualization interfaces (cf. [4]).
5. Arduino, Raspherberry Pi and other single board computers offer users cheap and easy ways to develop bespoke devices, wearable computers, or quick development of novel interfaces, which can be used to control and interact with visualizations,
6. toolkits such as OSC provide message forwarding among computers and devices to share gestures, parameters and other information, they can be useful to integrate together different technologies.
7. artists and designers are getting involved with this information visualization revolution, who are using mixed materials to create stunning visual and tangible interactive exhibitions.

The inclusion and use of multimodal devices in everyday live is set to increase, and consequently the development of non-visual modalities for visualization is bound to increase.

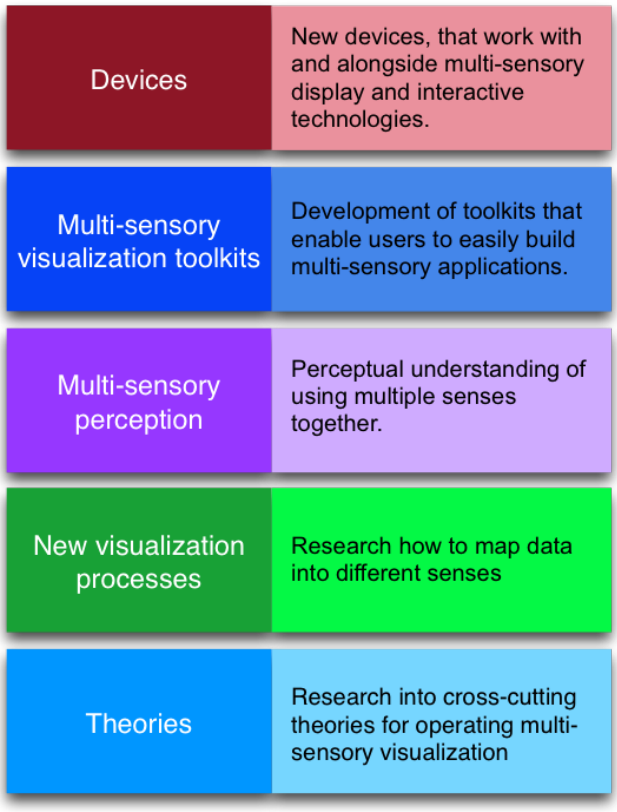

Figure 3: To reach our goal of a multisensory visualization workbench there are several areas that need additional research.

4 The Big Opportunity – Today's Research Challenges

Different sensory modalities are already being integrated into traditional visualization interfaces: where users can touch and feel the visual depictions. Touch is becoming ubiquitous through hand-held touch devices. Table-top displays, where users directly manipulate visual representations, are also becoming more common. On the one hand, Microsoft PixelSense tables provide fixed table environments; while mobile users are starting to expect touch interfaces in any and all display devices (from mobile phones, printers, cameras to microwaves and cars).

We are on the cusp of a revolution in information visualization research, where non-visual interactions from (say) touch screens with vibrotactile displays, small handheld computers with haptic feedback, etc. and other non-visual aspects will pay an important role in manipulating and perceiving data and information.

To get there, there are many research challenges that need to be addressed (see Figure 3. We need to: develop theories, research multi-sensory human perception for visualization, develop new procedures, new toolkits and new devices that enable users to perceive and visualize data through all of our senses.

There is thus a huge opportunity for visualization researchers: to develop multi-sensory visualization solutions. The time is ripe to think about these issues. Long live the data-visualization multisensory personal workspace.

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