Sensor Deployment

Martin Taylor
Martin Taylor Consulting
369 Castlefield Avenue, Toronto, Ontario M5N 1L4, Canada

Basic Question:

Why do users who **do not** want to be **flooded by data** want ever bigger screens on which to **display more data**?

It seems somewhat inconsistent for a commander to complain about the dataflood, while at the same time asking for screens that fill whole room walls, or for 3-D worktables that can present ever more data. Yet this is exactly what many commanders do. This presentation discusses the underlying factors that resolve the seeming inconsistency,

The Basic Question has two answers (both valid):

1. The more screen real estate, the more **context** of different kinds can be displayed for any item of focal interest.
2. Eyes **"flick"** more easily than screen data can be changed by interactive devices, meaning that both focus and context can be changed rapidly and consistently, with an easy return to the original focus and context once the information from the new place has been assimilated.

An eye-flick is the simplest kind of sensor redeployment. But it is like any other sensor redeployment in that it provides information about a new part of the environment, while losing the ability to gather information from the place the sensor observed before the redeploymnet. One always must balance gains and losses when redeploying sensors, but the gains and losses are not simply the gain of the new scene and the loss of the old.

One loss comes from the fact that the sensor is unusable during redeployment. Another loss comes from the resources needed to determine where the sensor should be moved, and to actually effect the move. In the case of the eye, it is often a peripherally observed movement or flash that tells you where to move the eye, and the eye itself is a lightweight sphere in a well lubricated environment, meaning that the movement can be quick and accurate, using few processing resources to determine the target of the move, little muscle power to effect the move, and little loss of observing time during the move.

In contrast to using an eye-flick, if the commander's display showed only the data relevant to the task at hand, sensor reedeployment would require some processing to determine what new data to select, attention to perform the selection, and substantial time-loss during the change. A very large display, then, if the content is appropriately configured, can allow the user to substitute a very easy eye-flick sensor redeployment for the more complex method of instructing the computer to display the data that are newly of interest.

Sensor Deployment

The example above contrasted the ease of an eye flick with the relative difficulty of obtaining the same change of seen data by asking the computer to change what is displayed on a small screen. Can either be equated with the redeployment of sensors on a battlefield? What can we legitimately call a sensor that can be redeployed?

A sensor is a device for bringing some aspect of the world into the range of a processor, whether the processor is a computer, a brain, or a burglar alarm. Any sensor sees only some of the available data at any one time, but if the data change slowly compared to the rate at which the sensor can be moved to a new part of the dataspace, then the data can be scanned and built into a larger picture. Alternatively, if a sensor with a wide field of view can detect a change in a part of the dataspace not seen by a focal sensor, then the focal sensor can be redeployed to examine that part of the dataspace more closely.

Dataspaces occur not only in the natural environment, but also inside computers, and dataspaces inside computers are the ones we have a problem visualising. To get the data into the brain requires

"engines" that select data, process it, and prepare it for presentation through display devices. The combination of an "engine" (selector or analyser) with a display device can be considered a sensor"that allows the human to see into a data space in a computer—to visualise what the data mean for the task at hand. So, "sensor deployment" can then be taken to apply to the control of the engines, directing them how to select the data, because there is too much to see all at once, how to process it, because it is unlikely to be in a useful form initially, and how to present it, because there are usually many possibilities for the presentation of the processed data.

When we are talking about visualising the natural environment, the only mechanism that intervenes between the environmental data and the brain is the senory mechanism such as the eye, the ear, the arm and hand—unless, of course, the hand is holding a probing stick or is manipulating some kind of tool. When the hand is holding a familiar stick or tool, it sometimes feels as though one's self extends to the probing tip, rather than ending where the skin meets the tool. Control of the stick is effortless and requires no diversion of attention from the task of visuaalising the environment the stick probes. This observation raises a question and a claim:

Question: Where do "I" find a boundary? At the skin? At the end of the "blind man's stick"?

Claim:

- If a sensor deployment needs specific "conscious" commands it is part of the outer world.
- If a sensor is deployed in its arena easily, intuitively, and "unconsciously" it is part of "you", and makes you feel you are in the data space.
- If you feel "in" the dataspace, you will visualise its implications better than if you "observe" the dataspace through an instrument that requires conscious manipulation.

Resources devoted to controlling the sensor are resources not available to interpret the data. If attention must be devoted

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

to the procedure for seeing a new part of the data, or for seeing the data in a new way, itthat attention cannot be addressed to the data. That is the fundamental reason why the large screen across which a user can flick the eyes is usually preferred to a small screen that shows all and only the data relevant to the task immediately at hand.

Interacting with the interface Versus Interacting with the data

When we use a computer display system to view data held in the computer, logically we have to interact through (and with) an interface. But it need not feel as if we do, any more than the blind man's stick feels like anything but an extension of the blind man's self. The feeling that the interface has disappeared, and we are interacting directly with the data, is sometimes called "transparency", but that term, evocative as it may be, is a bit misleading. Is the action of the steering wheel of a car "transparent"? It is not conscious, and does not demand attentional resources, but it is not "transparent". However, the driver does not think of interacting with the steering wheel so much as of interacting with the other traffic on the road, and with the intended route. The steering wheel requires no thought. Route-finding may, and interacting with the other traffic does.

The interface for deploying a sensor may be more complex than a steering wheel. A steering wheel controls the car in only one degree of freedom, whereas to identify useful data and to arrange for its display in an intuitively effective way may require many degrees of freedom. To some extent, then, the ideal of a "cognitively vanishing" interface can usually not be completely achieved for sensor deployment when the sensors are the"engines" of a visualisation system.

To approach the ideal (meaning to deploy a sensor easily and intuitively) one needs three things:

- To know where the sensor should look
- To know how to get it there
- To have the means to use this knowledge easily

To know where the sensor should go, there are different possibilities:

- Context (fisheye, multiple views, big screen): The new location may be visible within the displayed context of the original presentation. This is more likely to be true with large displays, in which sufficient display space is available for both the focal and the contextual data.
- Alert system (preprocessors): Autonomous processors analyze the dataspace, seeking out parts of it that satisfy predetermined criteria. When such a location is found, a subsidiary display may show where the intreresting data may exist, or if it is in the already displayed context, that location may be highlighted.
- Memory of the configuration of the data: If the user wants to observe a new part of the data for some reason based on interpretation of what has already been seen, rather than because of the actual characteristics of the data at the new location, the user's memory of the data structure may be able to guide the transition.

To know how to get it there, only two possibilities exist:

- Navigation through the dataspace, observing different data processed in a common way. The navigation may be continuous, in the sense that the data shown have a natural property of neighbourhood and that the displayed data progresses through neighbouring spaces. Alternatively, the navigation may be discrete, in that the focus of the presentation is moved abruptly from one part of the dataspace to another, without passing through intermediate regions of the data.
- Dimensional control: The same or different part of the dataspace may be viewed in a new way, either by changing the processing of the data before presentation, or by looking at different aspects of the same part of the dataspace. Of course, navigation and dimensional control can be used in conjunction.

To have the means to use this knowledge

- Effective input devices matched to the navigation requirements. Even if the user knows where to look in the dataspace, and how to get the sensor to look there, this knowledge is of no value if the input devices do not allow for the appropriate commands to the sensor. Precision of control is important, because if the sensor deployment is imprecise, it will require attention for the "correct" selection and processing to be achieved.

Navigation implies understanding the structure of the data, an understanding that can be achieved in several possible ways:

- The current presentation may display enough of the data to allow the structure to be understood.
- The presentaiton may use a metaphor to previously known data space (e.g. the office desktop...)
- Learning, training, exploration
- Subject matter expertise

You can't be"in" the data unless you know how it fits together. But as the earlier discussion suggests, you can't be"in" the data unless, without having to think about it, you know where the sensor should go, how to get it there, and you have input devices intuitively suited to commanding the sensor.

Precision of control is part of ease of control. Imprecise sensor deployment often means "conscious" deployment – and destroys the feeling of being "in" the data space. Attention devoted to correcting imprecise deployment is attention not given to the real task.

Where do "I" end? At the limit of where my control of sensor deployment is intuitive, "unconscious" and"**precise.**

Discussion – Paper 27

Sensor Deployment

IST-05 reference model

Inner loop

We want big screen real estate, but don't want to be overwhelmed by data
Answer: The more screen real estate, the more context of different kinds
Eyes flick more easily than screen data can be changed by interactive devices

Need alerting system to cue user to focus on certain presentation

Feeling of being immersed in data – sensor deployment – putting you fingers where you want to, looking where you want, having control over your interaction with the data

We have limited focal attention – 1 or 2 threads

A sensor is a device for bring some aspect of the world into the range of a processor

A sensor for a brain includes your eye looking at the data that was obtained by some other sensor and into your brain

Where do I find a boundary, at the skin? At the end of the blind man's stick?

Claim:
Where you begin to have to explicitly command the senses to do something is where "I" end. If a sensor is deployed in its arena easily, intuitively and unconsciously it is part of "you"..

Interacting with the interface vs interacting with the data

Important to remember the data is not the real thing. To deploy a sensor easily and intuitively one needs to know where is should go
Context
Alert system

to know how to get it there
navigation – continuous? Discrete? Menus good for discrete
- exploration of data spaces
- effectiveness of obtaining data from the system may have a lot to do with the input devices that allow the user to interact with the data
- implies understanding the structure of the data
- metaphor to previously know dataspace
- learing, training, exploration
- subject matter expertise
-

dimensional control

to have the means to use this knowledge easily

At the limit of where my control of sensor deployment is intuitive “unconscious” and precise

Precision of control is part of ease of control.
Imprecise sensor deployment often means “conscious” deployment – and destroys the feeling of being in the data space

Fuzzy skin – where the end of your conscious deployment is dynamic. Orchestra leader, for example—his “skin” encloses the orchestra in the sense that control and interaction is full, intuitive, and broadband [at least for music production, at least for the duration of the piece].

Perceptual control theory

Training and discovery