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User expectations for the intelligent blackboard

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Abstract

In this paper we try to identify some user expectations that could drive the formal assessment of the requirements for an intelligent blackboard. We proceed by proposing some scenarios and the features suggested by these scenarios for an intelligent blackboard. Finally, we consider both the hardware and software developments that could lead to such a product in the future. © 1997 Elsevier Science B.V.

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1. Introduction

The present paper is rather unusual in nature. It does not present actual developments, but it is a statement from a (naive) user point of view of the desired features of a device for display and interaction based on an idealisation of a very common tool: the blackboard. We have called this device the *intelligent blackboard*, meaning that we want it endorsed with some intelligence, while preserving the appeal of a blackboard. We think that the natural community of users for this kind of device is the academic one, but it can also be of use for other intellectual, even artistic, communities. From a technological perspective, we consider the intelligent blackboard to be a big challenge. Its development requires a substantial advance in hardware and software technologies. Our aim in this paper is to motivate from a user position the need and advantages of such a device. We will try also to identify key areas of technological development that are priors for the development of the intelligent blackboard.

Our starting point is the consideration of the blackboard as an omnipresent tool for teaching and interaction. Despite technological advances it has not lost anything of its appeal, and it has not become obsolete. We believe the reasons for this persistence are related to its simplicity and archetypal nature. The blackboard is, perhaps, the simplest and most flexible device for representation of symbolic information. It is used everywhere for the transmission of knowledge and communication of ideas. It has one of the highest usability scores that any human tool may have: it is extremely robust and easy to work with. We would expect an intelligent blackboard to show the same usability properties. We try to identify key features that add up to its high usability. Also, we try to enunciate some new features that could be expected of an electronic device, and that could add up to the *intelligent* adjective. Obviously, the device we are thinking of could be used as a conventional computer (large) display for a multiplicity of purposes.

2. Salient blackboard features

We find that the most appealing feature of the blackboard is direct *hand–surface* interaction with the displayed information. We have become used to representation tools that have separate devices for interaction (keyboard, mouse, digitising cards, etc.) and display (monitor). Direct interaction, through sensitive displays, with the displayed information is usually restricted to very specific tasks. However, the recourse to hand–surface interaction is deeply rooted in our behavioural patterns: it is not uncommon to find rather experienced people fingering the monitor with the frustrated aim of changing something. Obviously, we do not claim this interaction paradigm as exclusive to the blackboard: writing on a piece of paper is another example of this interaction paradigm. Although the use of keyboards and other input devices can speed up specific tasks, our contention is that hand–surface interaction with the displayed information is preferred to manipulate complex symbolic information.

The blackboard has a high *size/resolution* ratio that makes it particularly well suited to deal with complexity. Complexity means that we need large schemes, diagrams, formulas, etc. to describe the object under study. In our teaching and researching experience, we have found many instances of

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problems and ideas that needed a blackboard to be expressed in a comprehensive way. Blackboards are large display surfaces that allow high resolution, so that large quantities of information can be shown simultaneously. For this task, the blackboard has excellent ergonomic characteristics. The user does not need to scale down his movements dramatically to fit in the imposed interaction-space. To achieve the same level of resolution, other interaction instruments impose fine-tuned control of the movements and some training. Moreover, the blackboard is also a display device for non-small audiences. Visibility at a large range of distances implies a great amount of *flexibility* of the display resolution.

A conflicting feature of the blackboard is that of *erasability*. The blackboard is a volatile surface that can be easily cleaned (well, almost always). The ability to perform arbitrary deletion is a positive key feature that adds up to the usability of the device when the user is producing modifications. But when the user tries to recover past displayed information, erasability becomes an inconvenience. Then, it means *volatility*: the device keeps no record of the past. Today, people who are used to computers consider this as a really negative feature. The spread of computers has introduced other new user demands, such as the assumption of *communication* between devices. Future users will naturally expect the contents to be easily stored and transmitted to remote places and devices.

A last feature of the blackboard is its *robustness* and *ease of use*. It may seem a naive assertion to say that the blackboard is a robust and easy-to-use device. A negative aspect of our familiarity with the computer world is that we have become accustomed to complex instruments that can fail for unexpected reasons and need some training before they can be used. The absolute reliability and ease of use of a simple device hardly seem features to be noted, but when they are imposed on its electronic relative they constitute very stringent requirements.

3. Intelligent blackboard features

We would expect an intelligent blackboard to preserve the appearance of a blackboard. That means the hand–surface interaction must be realistic. It does not matter much if the pointing instrument is a special pen or the bare finger, as long as the surface responds to the pointing movements in real time. The size of the surface must be within the blackboard scale. We expect the intelligent blackboard to show the same resolution flexibility as the traditional blackboard. As far as these aspects are preserved, we do not worry about the exact spatial disposition of the board. We will consider table-top and wall-hanging devices as the same device. For large audience expositions, we also expect high visibility in natural light conditions. Needless to say, the intelligent blackboard must be extremely robust and reliable.

From an electronic implementation, we expect some primitives for the manipulation of the displayed information to be available, much the same as the facilities of today's conventional painting programs, such as the ability to perform arbitrary drag and drop, give diverse geometrical definitions of the pointer display, colour definition, zooming, scrolling, and so on. Our basic requirement is that these functions could be performed through hand interaction. The ability to perform arbitrary zooming is a very interesting feature that scales up the concept of flexible resolution, listed above as a positive feature of the blackboard.

As well as being a proper blackboard, some intelligence can be expected of the intelligent blackboard. The most basic intelligent property is *memory*. The memory of the device ranges from the ability to store and retrieve a set of "blackboard frames" to the ability to manage a trace of the interaction events. It should provide the means to efficiently navigate through this trace, either to recover a lost display state or to recompose the sequence of events to produce something new. Once built up, a set of blackboard frames could be recovered at will (in sequence, at random or following a thread over hypertext links), much in the fashion of actual multimedia presentation programs. Navigation through the trace of display events is a more difficult concept to grasp and realise. It involves the convenient storage of partial information about display modifications and the specification of a manageable visual representation of these past events that would allow easy navigation.

The reader must keep in mind that the information produced by hand–surface interaction is basically a form of handwritten information. We would expect the intelligent blackboard to perform *recognition* on this information in order to interface with the computer programs available to the user. Handwritten information could be interpreted as system commands, calling the execution of programs with certain parameters (pointing and clicking included). Handwritten information may itself be input to all kinds of text and graphics editing programs. (Of course we, technically oriented, are thinking of CAD drawing and equation editing, but text editing is also included). It seems more sensible to write a book (novel, essay, etc.) using a keyboard, but there is still room for many editing tasks that would benefit from hand–surface interaction and that involve a great deal of character recognition. In summary, we would expect the intelligent blackboard to perform, in real time, many large-scale handwritten recognition tasks. Handwriting recognition (characters, drawings, formulas, graphics, etc.) is the key feature to add to an unending list of computational features for the intelligent blackboard.

4. Some user scenarios

Let us proceed to describe some scenarios of interaction. Our purpose is to highlight from the user point of view the desired capabilities of the device to fulfil some task. These scenarios propose a categorisation of the main user populations that could find the intelligent blackboard useful. We hope that this paper will be the first step in a series of works that will produce more detailed formal assessments of user needs.

4.1. Teaching

Teaching is very complex process that involves several stages. Our emphasis is on technical/scientific teaching, but we believe that more literary/philosophical/artistic environments follow the same patterns although, from our limited knowledge, we believe that they could be less dependent on written specifications. We are also assuming that handwritten information is more "friendly" and more likely to be digested by the student, and produced by the teacher, than typeset information. The stages that we differentiate are: preparation, exposition and interaction, and finally, editing.

Preparation corresponds to building up a series of "blackboard frames" in which the teacher gathers and arranges the material intended for presentation in class. The materials range from text notes, rough drawings, schemes, formulas to image/sound/video illustrations. As the intelligent blackboard is a display device, all these materials can be supported by the same displaying device. Another consequence of the electronic nature of the intelligent blackboard is the immediate ability of the teacher to carry its presentation from the office to the classroom, and to share it with the students. (As can be done with conventional computers.) We believe that a substantive advantage of the intelligent blackboard is the increase in the efficiency of composition allowed by hand–surface interaction. The search for the most convenient spatial disposition of the information would be much more efficient in this paradigm. Rough drawings could easily be done, refined, and even recognised and translated into standard typed text, graphics, and so on.

In the exposition and interaction stage, the teacher confronts the audience. The exposition is a navigation of the set of blackboard frames. However, classroom teaching produces some interesting situations in which the carefully prepared notes could need some modifications: some detail was wrong on the original notes; a student proposes an alternative way to demonstrate something, or any other brilliant idea; the whole structure of the presentation was a failure; the content was good, but the order of presentation was bad; some new example or a new line of reasoning is revealed through discussions with the students or by the mere effort of trying to motivate them to listen. All these modifications could be performed by erasing and/or rewriting some pages, or by generating a whole set of new pages and linking them to the old ones (always under the hand–surface paradigm). The teacher, obviously, wants the modifications to be stored for future reference and meditation. The students want to be sure of having a copy of the modifications, and the dean could also want to have a record of the classes, just to measure the quality of teaching at his college.

Ideally, the editing stage follows after a long teaching experience. The materials are clearly defined, the sequence of presentation, the notes, problems, etc. are clearly set after a lot of interaction and learning experiences. The role of the intelligent blackboard at this stage is more concerned with the conversion (recognition) of handwritten information and the definition of the final layouts of the printed edition of the class materials. As stated before, we believe that hand interaction over a large surface will greatly improve the ability to define the spatial setting of the materials.

4.2. Engineering/scientific tasks

The next step is the generalisation of the hand–surface interaction paradigm to a general computing environment. The most interesting instance, from our point of view, is an engineering/scientific task. In this scenario, the display configuration could be much similar to a conventional workstation: windows define the interaction space with active applications that range from numeric/symbolic maths solvers to 3D graphical design programs. The mathematical applications would understand and solve handwritten posed problems. The graphing programs would start from handmade drafts, allowing their refining up to any desired degree of geometric definition accuracy. This scenario would include other kinds of computing and communication needs, such as the manipulation of databases, network access (internet browsing), application programming, etc. For these more conventional computing operations, the intelligent blackboard is reduced to a very large display device. However, basic hand–surface interaction would be very effective for navigating through the display space.

4.3. Design-team work

A team working on a design can serve as the paradigmatic example of a dialectic process in which all the audience members act as equals and try to reach a goal through argument competition. A group of engineers work together to fulfil a design task. The intelligent blackboard would then fulfil the role of a symbolic battlefield. The engineers may or may not be physically in the same room. They may define a virtual space for teamwork on their particular blackboards or share a single actual blackboard. In any case, we distinguish two basic kinds of group dynamics. In the first, each member of the team has a separate set of blackboard pages and he is unequivocally identified each time that he introduces or erases information. Other team members can review and reference his work, but they are not allowed to modify it. In the second, there is no identification of the team member that interacts with the pool of blackboard pages. Each team member can modify it at any moment and there is no individual copyright. In both cases, the ability to navigate through the trace of displayed events is a powerful feature. Also hand interaction remains the most immediate form of interaction.

4.4. Other intellectual activities

The hand–surface interaction paradigm of the intelligent blackboard could be the ideal canvas for a painter. Also, it would allow collaborative work and highly interactive artistic education. The size/resolution ratio of the intelligent blackboard could be a very interesting feature for other intellectual activities that involve complex displays. For example, the intelligent blackboard could be the ideal device to visualise and manipulate very complex music scores.

5. Supporting technology

We can find some products on the market that could be seen as precedents that point towards the future intelligent blackboard. Some companies produce whiteboards with digitising grids that allow to generate rough hard copies of the board's surface. Recent products (i.e. the product advertised at http://www.softboard.com) use laser triangulation to obtain a more accurate digital representation of the figures drawn in the board, and allow downloading into desktop computers for storage, manipulation and transmission. There are also products that provide real-time recognition of handwritten information (i.e. the Newton message pad from Apple) at small scale (320 × 240 pixels). Shared whiteboards are increasingly used today in the context of videoconferencing as broadcasting devices for graphical information.

In this section we will discuss briefly the advances that could lead to the feasibility of the intelligent blackboard. Although many of the basic features may be present in present-day technology, we feel that there is an order of magnitude gap for the currently available technology to support the intelligent blackboard.

5.1. Hardware

The basic hardware requirement is the availability of very large displays (1 m × 2 m at least), with high resolution and luminosity. An intelligent blackboard must give the ergonomic features of a ''real'' blackboard. As far as we know, conventional display technology is far from this goal. Large displays can be built up by assembling small patches, and are actually used in some cases, but this solution would produce very unnatural results as a blackboard. Also, the hand–surface interaction paradigm imposes the displays to be whole-area sensitive. There is still a very long way to go to obtain touch-sensitive displays with the resolution required to produce the required effect of free drawing on a surface.

Each ''blackboard page'' would consist of millions of pixels. This magnitude has severe effects on the scaling of the entire system. First, real-time refreshing of the display would involve the design of appropriate (distributed) architectures to support the display and interaction. Second, storage requirements for any of the scenarios described above would be astronomical by today standards (in the order of terabits for the average user). Third, the processing power needed to recognise large-scale handwritten information in real time is extremely high (on the scale of today's super-computers). From the information processing point of view, it could be possible to built up a prototype intelligent blackboard with today's (expensive) resources. But the day for the intelligent blackboard to be a commodity is still far ahead.

5.2. Software

From the software point of view, a main challenge is the processing of massive free-style handwritten information. Today's standards for compression of images (fax, JPEG, etc.) do not look good enough for the high ratio of quality/compression required. Also, new ways of define progressive compression methods would be needed to support the interactive generation and recovering of blackboard pages. Managing the interrelation and the trace of blackboard designs, which can include other information sources besides the result of hand–surface interaction, would involve elements already present in hypertext browsers and database management systems. But the robustness and usability of these systems are still far from our ideal requirements.

Some of the above scenarios need very powerful recognisers of handwritten information. The intelligent blackboard would involve systems able to understand many kinds of alphabet, to discriminate specific features (italic, underlined, etc.), and to read mathematical expressions and formulas. We include in this category systems able to interpret hand-drafted graphical/geometrical information. This is one of the greatest gaps between present-day technology and one that could give way to the existence of the intelligent blackboard.

6. Conclusion

In this paper we have introduced a device that we have called the intelligent blackboard, which we conceive as an ideal electronic realisation of the blackboard. It is not proposed as a near-term realisable product. We have drawn a picture of the features that we would expect of such a product. Given our own background, the main emphasis is in a teaching setting. Nevertheless, we believe that the intelligent blackboard could be a very useful tool in other situations. Finally, we have briefly discussed some technological aspects that we feel are key to the future realisation of the intelligent blackboard.