Interactive “Immaterial” Screen for Performing Arts

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ABSTRACT
Various performing arts increasingly employ projection screens and other information displays as essential elements of the show. We present some possibilities and lessons learned for the interactive, “immaterial” walk-through FogScreen in performing arts, analyze its suitability for stage setups, and give some guidelines for show design. We also describe our experiments on composing interactive 3D graphics for a FogScreen-based performance.

Categories and Subject Descriptors
J.5 [Arts and Humanities]; H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities; H.5.2 [User Interfaces]: Graphical user interfaces; I.3.6 [Methodology and Techniques]: Interaction Techniques; I.3.8 [Computer Graphics] Applications.

General Terms
Performance, Design, Experimentation.

Keywords
FogScreen, performing arts, interaction, 3D graphics.

1. INTRODUCTION
The StarWars-like mid-air displays have intrigued peoples’ imagination for decades. This kind of display would be very useful also for performing arts. Projection screens and other displays are increasingly used in performing arts, but typically they are non-permeable. A simple walk-through screen could be a large sheet of paper onto which graphical elements can be painted or projected, but it is not repairable.

We present some possibilities and lessons learned for the interactive, “immaterial” walk-through FogScreen in performing arts, analyze its suitability for stage setups, and give some guidelines for show design. We also describe our experiments on composing interactive 3D graphics for a FogScreen-based performance.

2. RELATED WORK
Traditional screens are not penetrable. There are many kinds of water screens, which spray sheets of freely flowing or high-velocity water to create impressive giant displays for large audiences. These screens would make the actors wet and the floor slippery, and thus they are impractical for indoors or performing arts where interaction or walk-through with the screen is required.

Illusions like Pepper’s Ghost, props and special effects have been used in theaters for long time. Computer graphics like in Krueger's Videoplace installations and Vivid Group's Mandala environments, and computer-controlled autonomous actors have also been tried [8] recently. New display technologies like Holoscreen [6] and other similar screens are transparent solid sheets that have a holographic optical element that enables to project an image onto it from 30-35 degree’s angle, and ignores all other light. These types of transparent displays are not penetrable.

Many types of fog projection systems have been used in art and entertainment for over a century, but the rapid dispersion of fog seriously limits the fidelity of projected images. The dispersion is caused by turbulence and friction in the fog’s flow, which disrupts the desired smooth planar surface, causing projected points of light to streak into lines and severe distortion of the image.

3. THE WALK-THROUGH SCREEN
FogScreen [10] is a commercial, patented product that can realize the mid-air effect in the optimal way on a two-dimensional “immaterial” image plane. It creates a large non-turbulent airflow to protect a dry fog layer inside it from turbulence. Unlike many other screens, FogScreen does not restrict the performer from walking through the screen, and can also hide him/her behind it.

FogScreen is currently available in standard 2-meter-wide size and in modular 1-meter-wide size, which enables any width with several units linked together. The FogScreen device is rigged above the heads of the actors so that they can freely walk through the screen, which forms under the device. FogScreen works much like an ordinary screen in terms of projection properties. The resolution is not quite as high, but it works well for most applications. The company’s web site [5] has more information and videos.

Also interaction with the immaterial 2D or 3D graphics objects can be implemented directly by touching them. An essential component for interaction is tracking of the performer. We have used several tracking systems to enable 2D and 3D interaction [11][13][2] for FogScreen. In addition to these, many other kinds of trackers could also be used. FogScreen has however some special features, and they may need some modifications.

For 2D tracking, we have modified products like eBeam [3] and Sick laser range scanner [7] for our purposes. eBeam is based on ultrasound and performs well, but it requires a hand-held pointer.

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The latest model does not have sufficient tracking range for the big 100” FogScreen, but previous eBeam model can handle it. Laser range scanner is more magical, as it requires no hand-held pointers or user-mounted markers, but it may behave in unexpected ways, if it takes unintended reflections from fog or the actor.

As a 3D tracker, we have used WorldViz PPT wide-area 3D optical tracker [8]. It uses infrared LEDs as head-mounted transmitters and 2 or 4 cameras to track the LEDs. The infrared signals travel through FogScreen without any problems due to its translucency, which can’t be achieved with traditional screens.

4. VISUAL DESIGN GUIDELINES

Some special properties of FogScreen needs to be taken into account, when designing a show. Animations, still images, videos, 3D graphics and other types of content can be used. Most images look good on FogScreen. However, there are some guidelines for the imagery and installation to ensure optimal visual quality.

The ambient lighting, screen background and projector’s, FogScreen’s and audience’s relative position will have a crucial role in the viewing experience and will impact the visual design of the presentation. The best viewing experience results, if these can be controlled, as is usually the case on stage.

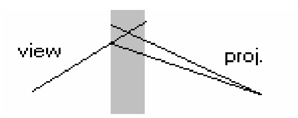

Figure 1. As FogScreen image plane is not infinitesimally thin, the pixels may mix with the neighboring ones, if the image is viewed or projected very off-axis.

Because FogScreen is a living surface, and because it is not infinitesimally thin, both the viewing and projection angles (and distances) have an impact on image quality (see Figure 1). When viewed from the side in a big angle, the screen becomes blurry, and narrow visual elements may even disappear as the neighboring pixels tend to smear a little due to the thickness of the screen. This is not a problem for a typical setup in performing arts, as the audience is usually tightly located near the optimal viewing area of FogScreen. Luckily, the long viewing distance also helps.

As a general rule, bright colors and high contrast between the graphical elements should be used. Very small text font sizes are legible only when viewed towards the projector, and blurred when viewed from sides. Bigger font sizes are more legible. The contrast between text and background should be high. Stage environments typically do not use very small visual elements due to the big distance of the audience, so this is not an issue.

The best image quality can be gained if the projector can be placed to about 6 meters or more from the screen, but shorter projection distances can also be used. Very big projection angle, as is the case with ultrashort throw projectors like NEC WT-610, is not recommended, as it reduces the visual quality significantly.

As with any screen, the projection size and the ambient lighting has a big impact on the brightness. Too much ambient light makes the overall image dim and dark colors may not reproduce well.

A window or bright lights right behind the screen shines through and may ruin the show. A dark background wall or drapes is very useful for the screen. FogScreen passes (misses) some of the projected light, so a bit brighter projector than usually is needed. 5000 ANSI lumen data projector is usually enough for typical setups, if the background is dark.

The image can be made brighter and more opaque by adjusting the image brightness, projector brightness and/or fog density very high. The image can be made very translucent with the opposite. Laser or gobo projections can be extremely bright, but they are limited to still images or limited moving effects. With them also some caution is needed for not harming any eyes.

Only rear projection works well on FogScreen, as it reflects hardly anything back towards the projector side. Rear projection is much brighter than front projection. This feature can also be used to create a two-sided screen. With equally bright projectors on each side of the screen, the same image or even totally different images can be shown on the different sides without any cross-talk. As the audience is typically located on one side of the screen, the two-sided feature is not usually needed.

The lamp of the data projector (hotspot) may blindfold some viewers. It is usually best to place the projector so high that the hanging device itself hides the hotspot. Projector’s sufficient keystone correction is then important. If the audience is sitting down, the projector can also be put down on the floor and project slightly upwards to prevent the hotspot.

The lower part of the screen is more turbulent, and it is thus not recommended to place small visual elements there. The lower part still produces an acceptable image quality for most applications. The image quality depends also on if the projector is placed up or down. Aspect ratio 16:9 (widescreen format) looks a little better than normal 4:3, as it utilizes the best upper part of the screen.

Wide zooming range of the projector lens is useful, if the screen is frequently installed to various places. High contrast ratio of the projector (800:1 or more) is also useful, if bright objects floating in thin air are intended to be shown, in order to make the black areas of the image as black as possible (to make fog invisible).

FogScreen can be extended to become a penetrable virtual reality screen with 3D tracking of the actor’s head [2]. This is however not needed for stage applications, as the correct visual for the audience is the main thing, not the actor’s subjective view.

Stereoscopic views can be generated with active or passive stereo, but this feature is not very useful for performing arts, as the human stereoscopic vision range does not extend to over 5 meters distance. Also the screen is smaller than in 3D movie theaters.

5. USING FOGSCREEN ON STAGE

Stage is one intriguing application for the walk-through screen. It can create a visual effect of 3D objects floating in thin air, and the performer can freely walk around and through the screen and interact with them. The screen can be made very translucent, or almost opaque by adjusting the projected image and the amount of fog. The screen is also DMX-controllable, so it suits well for professional audiovisual setups.

Actor Markku Laitinen has created performances for FogScreen since 2003. Using mime and physical theater he tells stories based on the classic commedia dell arte character. His FogScreen performances have taken place e.g., in Tokyo, Pyongyang, and Los Angeles at SIGGRAPH 2005 [12].

Figure 2: FogScreen is a new visual element with its walk-through and interaction possibility.

Mr. Laitinen's performance uses the interactive FogScreen as an essential visual element (see Figure 2). The technology provides the performer with an unforeseen range of new possibilities visually and functionally, e.g., playing with projected objects and entering the scene from behind the opaque screen. It is visual, stimulating and gives a totally new level of illusion to the stage.

For large part of the play the type of the screen does not matter as long as there is a visible image. In some crucial parts of the play the walk-through feature is very useful. There is e.g., a scene where an old, dying man slowly limps to the other side of "life's fog veil" to discover a brighter, better other side. The man is visible all the time, and the scene gives a stunning emotion of the man's end of life. FogScreen makes it easy to realize the scene.

FogScreen can be used as a passive projection screen, or as an interactive touch screen. Actually, true interactivity is not necessary for a scripted, timed play. A professional actor can synchronize acting and visual background by following the soundtrack and by getting hints from the visual (if he sees it at all, depending on which side of it he is standing). The first plays were in fact timed like this. However, true interaction based on actor's touch gives more possibilities for choreography, staging, special effects etc., and can give a more precise synchronization. Interactivity with FogScreen may also produce unintended errors, depending on the content and the used tracking method.

FogScreen has been used also on many other events and shows. Kreml Ballet Theatre in Moscow, Russia (see Figure 3) has employed a FogScreen as a dance-through element. Some rock bands have used FogScreen in their shows. Night clubs and entertainment industry in general have used FogScreens for various shows.

Several TV studios have used FogScreen for live shows and recorded episodes. FogScreen is used e.g., to spice up a studio setting in the "Nashwa" talk show for Dubai TV, recorded in Cairo. Some others like TV5 in France has used it in dance shows.

FogScreen helps to create backgrounds and special effects to the overall production of the show. Although special effects could be created in post-production or even in real time with augmented reality TV, FogScreen is more suitable for live setups, as also the actors can see what and where is being shown. The screen also helps to create special effects for the recorded episodes fast and economically, as no post-production is needed.

Figure 3: FogScreen in a ballet premiere of Kreml Ballet Theatre in Moscow, Russia.

FogScreen is commercially available, but it has been feasible only for high-end shows. The price is perhaps the most limiting factor for small productions at the moment.

6. PROGRAMMING FOR PERFORMANCE

We use a novel game development system to program the performance of an actor on a FogScreen. Our system is made up of an authoring tool and a logic engine.

The authoring tool is used for defining the sequence of and relations among event units that make up a performance. These event units could be anything from introducing an object to the screen, animating an object on the screen, removing an object from the screen to playing pre-recorded music, speech, or special effects sounds.

The authoring tool is also used for associating the event units with certain objects on the screen so that the performing actor can trigger these event units by "touching" the associated objects on the screen. Once an event unit is triggered, it can result in the automatic realization of a sequence of other event units as well, if programmed as such by a "performance author." At any given time during the performance, the actor can touch any one of the interactive (i.e., event-triggering) objects on the screen, and by his/her choice of objects, he/she can alter the flow of audio-visual events during each performance. Thus, the authoring tool allows for the programming of a variable performance scenario, i.e., the performance can follow different paths based on the choices made by the actor during the performance itself.

The logic engine is used to manage the flow of events in real-time during the realization of the performance by an actor. The design of this engine is based on the work done for the development of the adventure game Culpa Innata™ [1].

The logic engine is a Windows executable that takes as input a performance scenario created using the authoring tool and a database of all audio-visual events created for the performance. Once an event unit is triggered by the actor, the logic engine renders the associated audio-visual content such as 3D objects and their animations that is to be displayed. It then updates the set of currently available interactive objects on the screen. The engine is also equipped with a “virtual performance” tool which is designed to test and improve the flow of event units in a performance before creating the actual audio-visual content to be used during the performance. Hence, it provides significant savings in development time by allowing a virtual test of the performance before any content creation.

7. LIFE-LIKE CHARACTER ANIMATION

One of the main advantages of the proposed visual arts performance system is that one can easily incorporate animated life-like characters into the actor’s performance. In order to achieve this, we use novel methods for 3D personalized face model creation and face animation with lip synchronization.

The 3D face models are generated using 2D photographs of a person who is to be made a part of the performance. Given multiple 2D photographs, 14 locations on the person’s face are specified as the feature points on the photographs. These points are manually marked on all photographs where they are visible. Given the 2D locations of the feature points in the neutral images where they are visible, the 3D positions of the feature points of the person’s face are calculated [4].

The estimated 3D positions of the feature points of the person’s face are used to globally deform an initial geometry mesh to match the relative positions of the feature points on the globally deformed geometry mesh and to match the global proportions of the face. Following the global adjustments made to the face geometry mesh, each and every node of the geometry mesh is attached to, and hence controlled by, a triangle of a lower-resolution control mesh [4]. Once the geometry mesh is attached to the control mesh, local modifications to the geometry mesh are automatically made by moving the nodes of the control. The animation of the geometry is realized by moving the nodes of the control mesh.

It may be desired to add a conversation, i.e., a dialogue, with a life-like character displayed on FogScreen during a performance. A face animation tool is developed that allows performance designers to easily create and edit facial expressions of life-like characters during such a dialogue. It also displays synchronized lip animation so that the overall animation of the face can be observed when defining facial expressions. The major factor giving the facial animation a realistic look is the synchronization of the lips with the given speech. In order to create a realistic lip animation, we use the phonetic expansion of each spoken word in terms of phonemes and then estimate the phoneme boundaries for the given speech data. That is, the given speech data is aligned with its phonetic expansion. Then, each and every phoneme is mapped to a visual expression of the lips, which are called visemes and the 3D face model is animated using the sequence of these visemes.

8. CONCLUSIONS

FogScreen suits well to stage applications and can enhance many kinds of shows and performing arts. It brings a magical element and new possibilities to the show and can stun the audience, if well done. There are however some visual design issues with FogScreen that need to be taken into account. We have given guidelines for visual design and installation issues. We also present an authoring system, which suits well for making performances.

9. ACKNOWLEDGMENTS

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10. REFERENCES

[1] Culpa Innata™, http://www.culpainnata.com, August 2006.

[2] DiVerdi, S., Rakkolainen, I., Höllerer, T., Olwal, A., A Novel Walk-through 3D Display. SPIE Electronic Imaging, Stereoscopic Displays and Applications XVII, San Jose, CA, USA, January 15-18, 2006.

[3] eBeam tracker. Luidia, http://www.ebeam.com/, August 2006.

[4] Erdem A.T., A New method for Generating 3D Face Models for Personalized User Interaction. 13th European Signal Processing Conference, September 4-8, Antalya, 2005.

[5] FogScreen display. FogScreen Inc., http://www.fogscreen.com, August 2006.

[6] dnp Holo Screen. DNP, http://www.dnp.dk/, August 2006.

[7] LMS200 laser scanner. Sick, http://www.sick.de/, August 2006.

[8] Pinhanez C., Bobick, A., "It/I": A Theater Play Featuring an Autonomous Computer Character. Presence: Teleoperators and Virtual Environments, vol. 11 (5), pp. 536-548. 2002.

[9] Precision position tracker. WorldViz, http://www.worldviz.com/, August 2006.

[10] Rakkolainen, I., Palovuori, K., A Walk-thru Screen. IS&T / SPIE Electronic Imaging 2002, Proceedings of Conference on Projection Displays VIII, San Jose, CA, USA, January 23-24, 2002. 17-22.

[11] Rakkolainen, I., Palovuori, K., FogScreen – An Immaterial, Interactive Screen. Society for Information Displays (SID 2005) Invited paper. Boston, MA, USA, May 22-27, 2005.

[12] Rakkolainen, I., Laitinen, M., Piirto, M., Landkammer, J., Palovuori, K., The Interactive FogScreen. A demonstration at ACM SIGGRAPH 2005 Program: Emerging Technologies, Los Angeles, CA, USA, July 31-August 4, 2005. 127.

[13] Rakkolainen, I., Palovuori, K., Laser Scanning for the Interactive Walk-Through FogScreen. ACM Symposium on Virtual Reality Software and Technology (VRST 2005), Monterey, CA, USA, November 7-9, 2005. 224-226.