

Projector Display Systems in Visualization

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Fig. 1. Three types of projector display systems seen in the Iron Man movies: (A) head-mounted projection that augments the normal vision of a user with processed information from the scene, (B) holographic projection that allows direct manipulation of the domain objects, and (C) immersive projection that goes beyond holographic projection to convert a closed physical space into an alternate reality for interaction with data. **Image Copyright:** Marvel Studios Inc.

Abstract— Modern films such as the Iron Man series, Avengers, and Pacific Rim best exemplify visual interface designs that are futuristic, follow fluid interaction guidelines, and are yet not too distant. These movies show interaction models designed for direct manipulation of real and virtual objects in holographic projections, and also embodied interaction in completely immersive environments. Furthermore, these imagined interfaces have their own envisioned application domains ranging from casual computing, information browsing to creative design and even analytics. A common aspect among these many imagined futuristic user interfaces (FUI) is projection of different types: (1) head-mounted, (2) holographic, and (3) immersive projection. In this paper, we imagine the interaction models that can best-fit each of these projector display types when they are adapted to visualization and visual analytics. For this, we consider interaction models that go beyond a desktop to utilize *implicit* aspects within the environment such as proxemics and *explicit* actions through direct manipulation, gestures, tactile, and other forms of multi-sensory feedback. We borrow application scenarios from the aforementioned movies and the general guideline behind our discussion is that *projection type guides the interaction design*.

Index Terms—visualization, interaction, projector displays, proxemics, gestures, post-WIMP interaction.

1 INTRODUCTION

User interfaces are evolving fast in modern films capturing many imagined fluid interaction models. Over time, special effects designers have done a great job in imagining the future of visual interfaces and sometimes even guiding visual interface design. These futuristic user interfaces (FUI) have evolved over the past decades, and many of these are now even possible through technological advances in sensing and display. For example, FUI from the movie Minority Report can be now prototyped with devices such as Microsoft Kinect¹, Leap Motion², and data gloves³. Also, modern CAVE environments⁴ partly resemble the fictional virtual and simulated reality environments (for e.g., HoloDeck from Star Trek). We believe that these FUI from the movies can, therefore, guide us towards imagining the future of visualization and visual analytics within this advanced display space.

Over the past decade, movies from the Iron Man franchise have shown fictional interfaces with holographic projection, head-mounted projection, and immersive projection environments. Figure 1 shows Tony Stark (played by *Robert Downey, Jr.*) and other characters interacting with these projector display environments. This pattern can be also seen in other movies and TV series; examples include Tron Legacy (movie), Pacific Rim (movie), Fringe (TV Show) and Continuum (TV show). While some of these technologies seem achievable in near future, interaction models for using these projector display sys-

tems in visualization and visual analytics are yet to be fully designed (or rather imagined). Note that we limit our discussion to projector display systems but other technologies such as transparent displays are also seen in many recent movies such as Avengers and Oblivion.

Existing research has already discussed guidelines for fluid interaction models in information visualization [1]. Modern interfaces in human-computer interaction [3, 7] also use *proxemics*, a theory first proposed by Edward T. Hall [4], for reacting to the spatial attributes of the users and objects within the environment. While these advanced interaction styles based on the implicit aspects are just starting to be used in visualization [5], we believe that they will play a major role in future visual interfaces along with various forms of explicit actions. In the next couple of sections, we describe these interaction models that are based on implicit aspects and explicit actions, and then apply them to projector display systems used in borrowed application scenarios (relevant to visual analytics) from the aforementioned movies.

2 INTERACTION DESIGN

The projection display systems from the modern films typically show characters interacting through gestures and direct manipulation of the domain objects through physical actions. However, we believe that these can be combined with interaction models that use the implicit aspects within the environment to reduce fatigue and the requirement for remembrance and recall. Examples of the information from the environment used in these interaction styles include:

S1 Implicit: The implicit aspects within an environment include *proxemics*, the spatial attributes of the users (and objects) within the environment, and also information from the native sensors within the devices including the gyroscope, gravity, Hall (magnetic) sensors, and accelerometer; and others such as thermal imaging, infrared, and lighting sensors.

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¹<http://www.microsoft.com/en-us/kinectforwindows/>

²<https://www.leapmotion.com>

³<http://theglovesproject.com/data-gloves-overview/>

⁴<http://www.visbox.com/viscube.html>

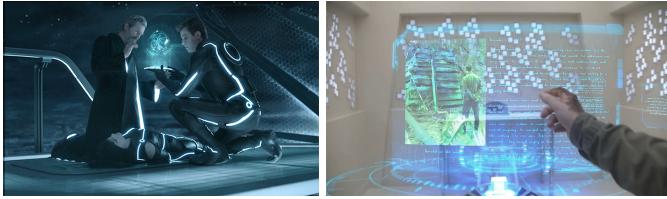


Fig. 2. Holographic displays from Tron: Legacy (movie) and Fringe (TV series). **Image Copyright:** (Left) Disney Enterprises Inc., (Right) Warner Bros. Entertainment.

For example, non-metallic objects within the environment retain thermal prints when users touch them and this print deteriorates over time. Usually users do not realize this as the print is invisible to naked eye. Therefore, it can be recognized to automatically adapt the interface to this implicit action.

S2 Explicit: Gestures are a common ways to express user intent in post-WIMP interaction. These are often pre-defined, fed into the interface, and taught to be users before actual interaction. Gestures can be defined to support different input technologies such as direct-touch and body-worn sensors (Vicon motion sensing⁵). With holographic displays, the ability to also directly manipulate the underlying objects through physical actions comes into picture. For example, editing a 3D model by squishing, squeezing, and folding the hologram.

While explicit actions act as an easy way to create advanced interaction models, they also require proper feedback loops to intimate the execution of an interface action. This feedback which can be treated as an explicit action by the computer system can be of visual, haptic, and other multi-sensory forms. Examples of 3D gestural interaction in information visualization are reviewed by Lee et al. [6].

3 ADVANCED DISPLAY SYSTEMS IN VISUALIZATION

As described before, we identified three different projection types seen in movies and in this section, we describe how implicit and explicit aspects can be used in designing interaction models for each of these projection systems:

3.1 Head-Mounted Projection Display

Head-mounted projections provide a way to augment real objects such as tables and walls without intruding on the view of other users. These projector displays [2] have a transparent glass in front of the user's eyes to overlay visual information over the normal vision of a user. As seen very frequently in the Iron Man series, the helmet in the Iron Man suit acts as an head-worn display and makes it possible for Tony Stark to analyze real-time data on the go. It is a requirement for such displays to not intrude the actual activity performed, but only aid in the process. Part (A) of Fig 1 shows an example of the view through the head-worn projector display from Iron Man.

The important aspect of this projector display is its ability to turn any real-world actor (a person or an object within the field-of-view of the user) as an information source. Generalizing the example of analytics from Iron Man, a regular police officer can use head-mounted projector displays to augment a crime scene with visualizations of the past statistics from previous cases, to observe commonalities and aid visual analysis. Interaction with these displays can be through speech (or pre-defined speech patterns like "Okay, Google"), but understanding natural language itself is a ardent task requiring a lot of advanced pattern recognition and context-sensitive grammatical models. However, if every object is an information source, then the interaction with the system can also be through the objects in the environment.

Explicit actions in such environments can be through surrogate interaction, for example, a pen placed at the edge of the display can be

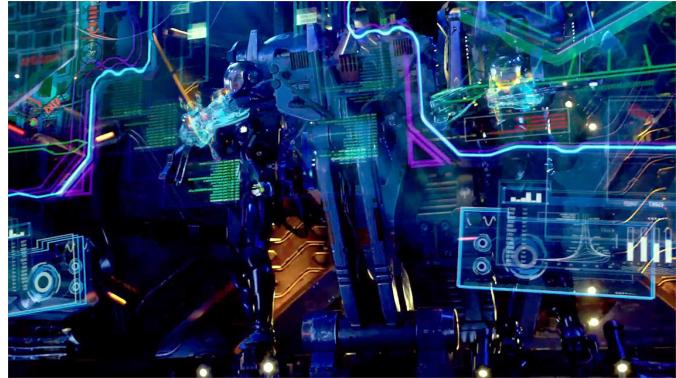


Fig. 3. Immersive environment from Pacific Rim. **Image Copyright:** Warner Bros. Entertainment.

rotated to represent a change in the mode of the visualization. Note that one needs to be careful while designing such a surrogate interaction style as some of the objects may be used for the actual activity (for the investigation in the previous example) and its required to distinguish objects that are in or not-in-active use. One way is to define an interaction model that is independent of the input medium, for example, a gesture in this system can be defined as a rotation of any arbitrary object (i.e., not a particular pen but any object registered as not-in-active use). For implicit interaction, these displays can adapt to the view direction of the users through gaze tracking.

3.2 Holographic Projection

Forbidden planet, a 1956 science fiction film, is one of the early movies to show holograms used for communication. This is later seen in the Star Wars series, and since then holograms have become one of the coolest and advanced futuristic technologies imagined by the special effects designers. Among recent movies and TV shows, holographic displays are seen in Iron Man for creative design (of the Iron Man suit as in part (B) of Fig. 1), in Tron: Legacy, and in Fringe (as shown in Fig. 2).

Direct manipulation can be the most fluid way to interact with holographic displays [1]. This involves interacting with the domain objects as if they are real (reality-based interaction). For example, in the second image in Fig. 2, holographic displays are used for analytics. This example actually begs the question, if holograms are indeed used for visualization in the future, would they change the representations of the visual interfaces and visualizations to go 3D rather than traditionally preferred planar graphs (such as line and bar charts unless there is a natural mapping to 3D).

In general for explicit interaction, direct manipulation, gestures, and pointing can be useful in this scenario. In terms of the feedback the explicit action by the computing system should fluidly reflect the change during direct manipulation in an animated way. These displays can be also be portable, in which case the information from the surroundings including the lightning settings, orientation of the projection, and the dimensions of the surrounding objects can be used to automatically adapt the holograms.

3.3 Immersive Projection Environments

Immersive projection environments are closed spaces of simulated reality and virtual reality, that go beyond using just holographic displays. While holographic displays can be portable, immersive environments are fixed and may use multiple holographic displays along with other display types. These environments were quite popular showing up as HoloDeck in Star Trek. Among recent movies, Pacific Rim showed such environment within the Jaegers (the giant piloted robots seen in the movie). The goal of this environment is to simulate alternate reality to provide enough context for an activity. In Pacific Rim, the activity was to pilot the robots and the immersive environment showed visualizations of the sensors on the robot (seen in Fig. 3).

⁵<http://www.vicon.com/>

These environments can use reality-based interaction from the users, however, considering that these environments can be large and induce fatigue over time, they can also benefit from smart gestures and pointing for explicit style of interaction. In the Pacific Rim example from the previous paragraph, there was limited interaction as the pilots were engaged in controlling the robots with their body. However, in general, these environments can also automatically use the implicit aspects including the user proxemics, mood, emotion for interaction. As in holographic displays, feedback also plays an important role in this projection system to enable the necessary realism.

4 CONCLUSION

In this paper, we provide design choices for interaction models in various projector display environments seen in the movies. We discuss design choices for implicit and explicit interaction styles within each of these advanced display environments. We, thus, open a discussion for further designs in this imaginary, albeit not too distant, space.

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