# FamiLinkTV: Expanding the Social Value of the Living Room with Multiplex Imaging Technology

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## ABSTRACT

In this paper, we will be introducing a technological solution enabling the use of multiplex imaging technique on the living room television screen. *FamiLinkTV* allows all the family members to enjoy an experience that goes far beyond the simple screen sharing together: instead of having different family members watching their own contents in their own rooms, or on separate time slots, *FamiLinkTV* aims to get people to sit on the same couch at the same time. The sharing of physical space will allow family bonding to take place by acting as a catalyst for social interaction. In order to involve more developers and artists in the search for innovative interaction-enhancing content, we opened the field for content creators by proposing a Unity3D plug-in that enables multiplex imaging on 3D flat panels. Current development allows contents such as games, movies and camera feeds to be displayed on the screen, and be seen independently in real-time, either on the naked eye (main content) or through cheap polarizing glasses (hidden content). The implementation of image hiding is likely to have a great impact on the current multiplex technologies.

## Categories and Subject Descriptors

I.3.1 [**Computer Graphics**]: Hardware Architecture—*Parallel processing, Three-dimensional displays*

I.3.3 [**Computer Graphics**]: Picture/Image Generation—*Display Algorithms*

I.3.6 [**Computer Graphics**]: Methodology and Techniques—*Interaction Techniques, Languages*

## General Terms

Algorithms, Performance, Design, Experimentation, Human Factors, Standardization, Languages.

## Keywords

Multiplex Imaging, Image Hiding, Unity3D, Home Entertainment, Display Technology



## 1. MOTIVATION

Currently, the living room is the center of family interaction, where parents and children can share the house's main display…as long as they want to watch the same content at a given moment! For example, children can't play videogames while their parents watch a movie. Sometimes younger family members are forced to leave because of the maturity of the contents being displayed. The strategies developed so far to satisfy all the viewers practically consist in having a TV in each room, or dedicated time slots: in a nutshell avoiding the other family members. So instead of contributing to social interaction, the living room's display might actually be a source of conflict, physical separation, and thus a potential communication breaker. The goal of the *FamiLinkTV* project is to provide a technology that could restore the living room's status as the center of family interaction: multiplex imaging allows viewers to share the same screen at the same time, but more importantly they share the same couch: physical space sharing is very likely to catalyze social interaction, in addition to the actual contents that can be specifically designed to enhance the "shared entertainment" experience.

## 2. CORE TECHNOLOGIES

### 2.1 Scritter / ScritterH

The FamiLinkTV project is the latest development of ShiraiLab's *Scritter* series, which explores the possible applications of multiplex imaging based on polarization. The purpose of *Scritter* [1] (Fig. 1) is to redefine the value of screen sharing, which is currently limited to multiplayer gaming in the market today: Sony Computer

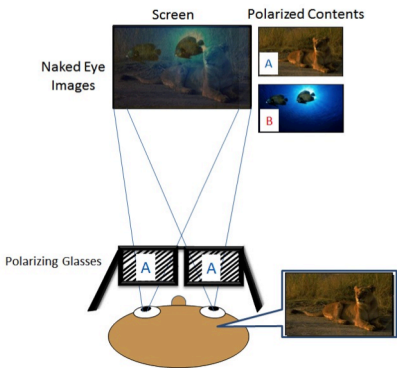



**Figure 1. *Scritter*: Multiplex imaging technology**

Entertainment's *SimulView* [2] or LG's *Dual Play* only scratch the surface of the amazing potential of multiplex imaging.
*ScritterH* (Scritter + Hiding) is a development of *Scritter* that introduced the ability to hide one of the multiplexed contents with a pixel shader [3]. Having a hidden channel invisible to the naked eye (Fig. 2) is a real breakthrough in the market of multiplex imaging and offers new fields of investigation for innovative applications [4]. "2x3D" [5] is one application of ScritterH which can realize 2D+3D hybrid display system thanks to this technology.

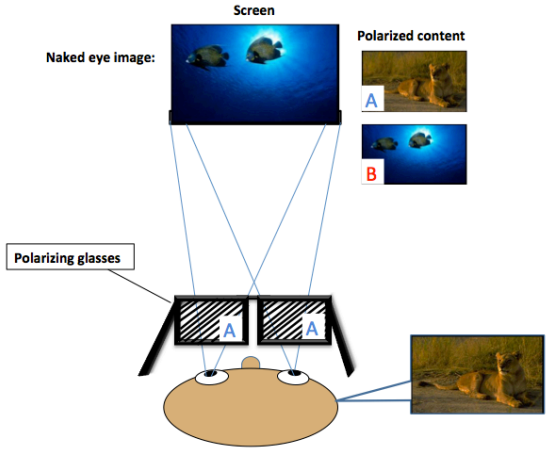



**Figure 2. ScritterH Multiplex hidden imaging**

## 2.2 Scritter for 3D Flat Panel

After successfully achieving multiplex imaging with LCD projectors, *Scritter* has been transposed to flat panels, which are more widely spread in households. This 4th generation of *Scritter* is based on the built-in polarization properties (directions A and B) of the 3D flat panels that are currently available on the market (Fig. 3).

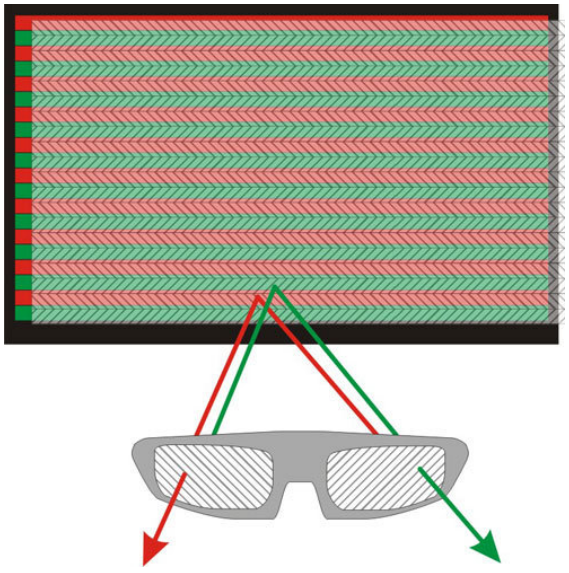


**Figure 3. Built-in polarization of a 3D flat panel**

This even/odd-pixel-lines distribution of polarization directions led us to create a shader that could display the first content on the even pixel lines of the screen, and the second content on the odd ones. The shader is based on the *modulo* mathematical operator to display two contents A and B. For each pixel defined by its (x, y) coordinates on the screen:

$$\mathbf{Output}(x,y)=\mathbf{A}(x,y) * y\%2 + \mathbf{B}(x,y) * (y+1)\%2 \quad \ldots \quad (1)$$

The Graphical Processing Unit can then run this simple program every frame, resulting in the superimposition of the two contents in real-time, meaning it can handle videogames and movies running at the same time (Fig. 4).

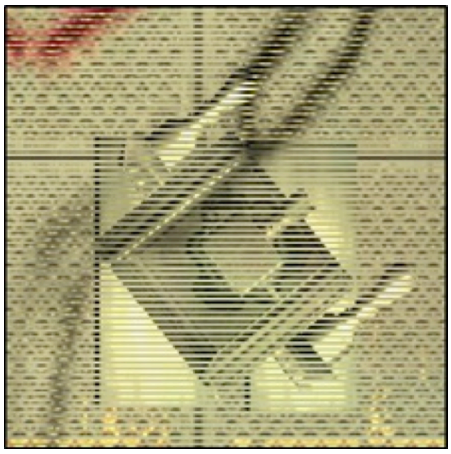


**Figure 4. Zoom at the pixel scale: superimposition of a videogame and a movie displayed on a plane**

The resulting image is a series of horizontal pixel lines displaying alternately contents A and B, matching the built-in polarization of the 3D screen. Contents A and B can hence be visualized independently through glasses with polarization directions A and B. Tests have shown that the loss in quality when dividing the screen (thus the vertical resolution) by two is compensated by the high initial resolution of the screen. The horizontal resolution is not affected.

# 3. SYSTEM OVERVIEW

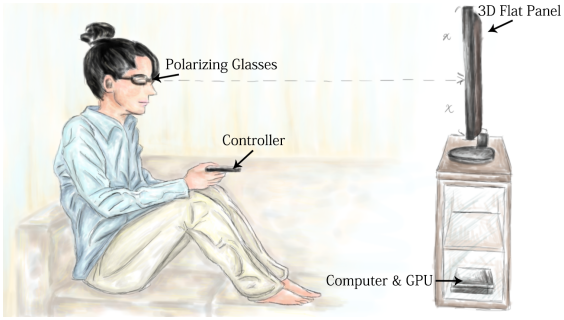



**Figure 5. System overview of FamiLinkTV**

*FamiLinkTV* was designed to be compatible with what is currently available in most living rooms (Fig. 5): this strategy makes the technology easy to be adapted by anyone who has a couch, a 3D flat panel and a computer. The current version of the multiplex image processing technology is exclusively software. After importing their favorite contents, the users simply have to run the executable file of the application. The content shown on each channel can be chosen independently while the application is running, just like regular channel surfing with the remote.

## 4. CONTENT CREATION TOOLS FOR SCRITTER WITH UNITY 3D

The potential success of *FamiLinkTV* is directly linked to the existence of a market for available contents. Regular contents such as movies or images can be set as input, but the true potential of the technology is the creation of innovative content specifically designed for multiplex imaging, and that could give a new value to home entertainment. This led to the creation of a Unity3D tool allowing application creators and artists to be involved in the search for new concepts. The current content creation process takes place in Unity3D exclusively, but this particular game engine is widely used by independent application creators: both the powerful Unity community and the *Unity Asset Store* (for content creators to actually earn money out of their contribution) justified this choice. The developed plug-in is a *Unity Asset Package* that can be imported into any Unity game. It consists of the multiplex shader, buffering render textures and some additional Unity objects (Fig. 6).

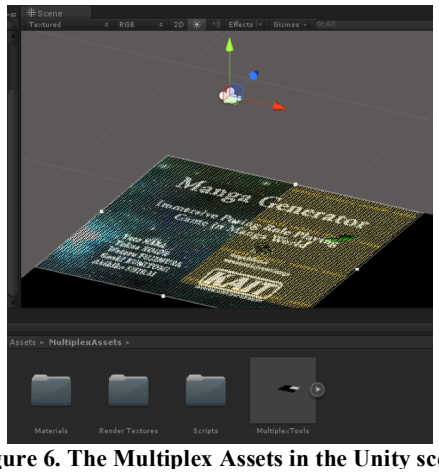
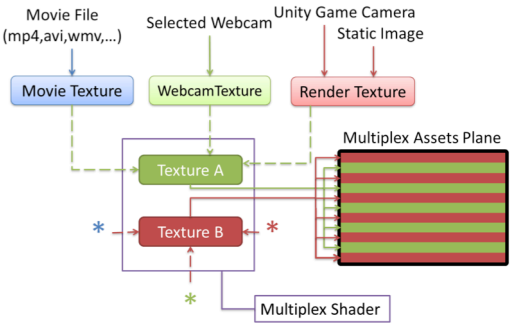



**Figure 6. The Multiplex Assets in the Unity scene**

A *Content Selector* script allows the user to assign what will be rendered on channels A and B. The actual merging of two contents is done on the package's *Plane* hosting the shader (Fig. 7). The *Plane* is then rendered on full screen for the pixel lines to match the screen's polarization. The two channels can then be watched independently through glasses of adequate polarization.




$$\boldsymbol{ShaderOutput}(x,y,t) = [\, \boldsymbol{a}^{\gamma} - \boldsymbol{b}^{\gamma} \,]^{\frac{1}{\gamma}} \times y\%2 \; + \; \boldsymbol{b} \times (y+1)\,\%2$$

with **a** = A(x , y, t), **b** = B(x, y, t),

* **γ = 2.2** (gamma correction)

**Figure 7. Asset Package and Multiplex shader, which is performed on GPU**

## 5. POTENTIAL APPLICATIONS AND IMPROVEMENTS

The main objective of *FamiLinkTV* is to encourage family members and friends to interact with each other while enjoying their contents on the same screen. Conflicts over time-sharing of the screen are solved by the ability to watch a movie on channel A (Fig. 8) and simultaneously play a videogame on channel B (Fig. 9).

Some games might contain inappropriate contents that are harmful to children, and instead of preventing adults from playing them or keeping children away from the living room when the game is being played, *FamiLinkTV* hides the inappropriate contents from younger audiences even when such contents are right in front of them. By creating two versions of the game and displaying the

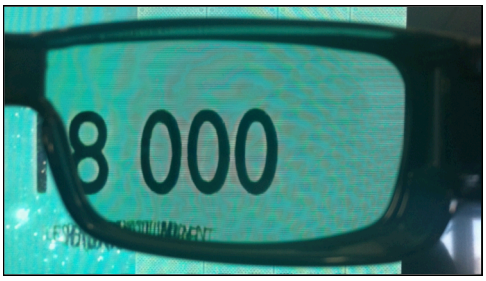


**Figure 8. Video player on channel A**

**Figure 9. Real-time videogame on channel B**

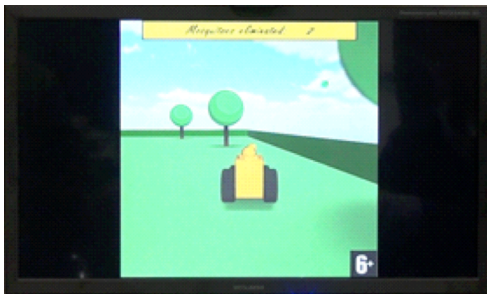



**Figure 10. The game scene by a young viewer on the naked eye**


**Figure 11. The same game scene by an adult on channel B with a filter**

children-friendly racing game (Fig. 10) in front of children while displaying the more violent contents (Fig. 11) in front of adults, *FamiLinkTV* allows audiences of different ages to play two versions of the same game at the same time. The key point of this application is that it is a multi-maturity cooperation game which can be played simultaneously by a daughter and her father, but still meets the gaming expectations of both of them.

By improving the multiplex imaging shader, we have successfully managed to completely conceal one of the channels on the naked eye, for still and real-time applications in Unity. Viewers can enjoy one of the contents just like any regular TV without wearing any glasses. The hidden channel can be visualized through the glasses (Fig. 12). Although the user has to find the "hotspot" for optimal vision, it is very close to the regular sitting position in the couch, and the large horizontal field of view allows many users to watch the hidden channel simultaneously. The potential applications of hidden imaging are numerous, and could be the future of home entertainment.

**Figure 12. Watching independent content simultaneously**

*FamiLinkTV* sums up the first investigation for innovative multiplex content: first we developed a 2 player racing game where both players see their point of view independently, the innovation being hiding player 2 and his in game view point from the naked eye. Another game mode allows cooperation between two players with one player playing the mature content while the other one the children-friendly content. It could be used to protect children from seeing inappropriate content, and still having two players having fun despite a maturity/age gap. Finally, the last mode enables movie watching and videogame playing at the same time, which eventually solves the issue of the fight over the remote at the time of the newscast.

Other potential applications for *FamiLinkTV* include multi-lingual content with hidden subtitles, in the context of international families or for the sole purpose of learning. Another field being investigated is the redefinition of "backseat gaming": instead of having a passive audience spectating the adventures of a single player, we can imagine applications where the spectators have exclusive access to hidden game content, allowing them to play an active role without actually playing with a controller.

The most significant improvement will be the implementation of audio, which is currently lacking in the *FamiLinkTV* experience. The challenge can be possible to add independent sound channels with HSS (Hypersonic Sound System) or audio spotlight [6].

## 6. CONCLUSION

*FamiLinkTV* is the latest development of ShiraiLab's *Scritter* series, transporting the multiplex imaging technology to the living room's flat panel. Its purpose is to solve issues of having a single screen for all the family members, which usually results in struggles for control over the remote, physical separation in each one's room, complicated time slots allocation, and generally a sad lack of communication in the family. In order to catalyze social interactions, *FamiLinkTV* enables family members and friends to watch their favorite contents on the same screen using the built-in polarization properties of 3D flat panels that hide unwanted channels from others. Dedicated innovative contents can help enhance the multiplex sharing experience: that is why we encouraged the search for new concepts by proposing a plug-in that could easily help application creators and artists to get involved in the content creation process. By improving the multiplex shader's mathematics, we were able to overcome the multiplex imaging technology's main weakness, which is the hiding of double image to the naked eye: since wearing glasses at all times can be a deal breaker for some users, we developed a solution that truly brings multiplex and concealment for the first time to flat panels. The results of the investigation for innovative content are shown throughout the *FamiLinkTV* experience.

## 7. REFERENCES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