Moving Innovative Game Technology from the Lab to the Living Room

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Video games have become a giant industry reaching a truly mass-market audience, while at the same time riding the bleeding edge of technology. In 2011, global video game revenues were estimated at well over $60billion. But since video games are entertainment, they offer a unique launch pad for new technologies because players are supportive and hopeful, and the focus is enjoyment rather than productivity or five-nines reliability. These technology advancements allow game developers to push the limits of possibility by exploring new experiences.

1 Innovative Hardware Technologies

Throughout the history of video gaming, game hardware manufacturers have produced significant innovations in the areas of computing, graphics, display, and input technologies. The interactive nature of video games drives technologies with requirements of high performance and yet low latency.

1.1 Graphics

An example of game graphics innovation is the Voodoo 3D graphics technology from 3dfx, a 3D-only graphics add-on card for PCs that enabled arcade-level graphics. In the same time frame, Nintendo released the Nintendo 64 "Reality" 3D graphics co-processor, which was touted as the equivalent of "a high-end Silicon Graphics workstation in your home". Several years later, Sony created the PlayStation 2 Graphics Synthesizer, which achieved enormous polygon fill rate due to its 2560-bit width bus to graphics RAM.

Games continue to be the driving force in real-time graphics hardware today, and are often used as benchmarks for measuring personal computer performance.

1.2 Computing

Game hardware manufacturers have also pushed the boundaries in computing, especially parallel computing. One of the most extreme examples of this is the Cell processor in the PlayStation 3, a microprocessor that consists of 1 general-purpose CPU and 8 co-processors intended for handling streaming computation like that often found in interactive applications. Another recent example of video games pushing the boundaries of computing is “cloud gaming”. Companies such as OnLive and Gaikai have demonstrated that high-performance gaming is possible using only a thin client by streaming output (effectively a movie) from a powerful server in the cloud. These companies are moving the bar for what type of applications can be moved to the cloud.

1.3 Display

Display technology is another area that game hardware companies have innovated. One of the Nintendo 3DS screens uses parallax-barrier technology to present a different image to the left and right eye, effectively creating a three-dimensional image with no need for glasses. The 3DS also includes a slider that lets the player control the strength of the 3D. The PlayStation 3D monitor, a peripheral for PS3, uses fairly standard LCD shutter glasses to achieve 3D, but it also uses this technology for an innovative “dual view” mode in which two players will see completely different 2D images. In the near future, low-cost Head Mounted Displays (HMDs) will provide a completely immersive 3D experience that updates the image shown based on the player’s head motion.

1.4 Input

In the past several years, video games have really pushed the boundaries of input technology beyond the joystick, gamepad, keyboard, and mouse. A primary reason for this is that the earlier rapid advancements of graphics and display technology (output) greatly outpaced the advancement of interface technology (input), thereby creating an unbalanced user experience.

Several key technologies for input have led this revolution in interfaces. The commercialization of MEMS (MicroElectroMechanical Systems) has made small, low-cost sensors a possibility, including accelerometers, gyros, magnetometers, pressure and temperature sensors, and many more. In conjunction with another enabling technology, namely wireless, high-speed, low-cost, low-power, low-encumbrance digital communication, these micro-sensors can be used to collect a wide assortment of data for processing. And finally, digital video cameras have become viable as low-cost input devices useful for interfaces as well as communication, when combined with the ever-growing processing capability.

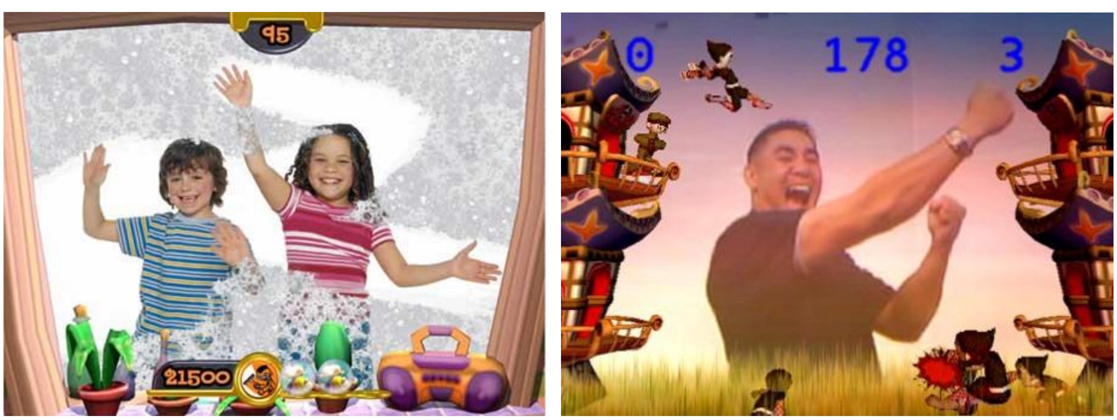

Figure 1. The EyeToy camera turns the television into an augmented reality mirror.

EyeToy for PlayStation 2 explored both enhanced reality (i.e. augmented reality) and video-as-input paradigms. The Nintendo Wii included a one-handed motion-sensing remote as its primary controller, redefining the way games are played. The PlayStation Eye camera for PlayStation 3 improved upon EyeToy, enabling new marker-based augmented reality experiences such as *Eye of Judgment* and *EyePet*. The Microsoft Kinect camera extended video sensing to capture depth information at every pixel, thereby enabling the Xbox to compute the dynamic pose of the player (i.e., skeleton tracking). Kinect also included a microphone array to enable voice control without needing to hold or wear a microphone. PlayStation Move combined inertial and camera sensing into a single system that provides high-precision, high-speed six-degree-of-freedom tracking of the one-handed controller. *Wonderbook* uses marker-based technology and PlayStation Move to create an interactive book. Each page of the "book" is printed with a different marker, so a unique interactive augmented reality experience is shown on the television for each page as the player flips through them.

Figure 2. Wonderbook uses PlayStation Move and a "book" with different markers on each page to create a rich augmented reality experience.

2 From lab to living room

Transitioning new technologies from research to product in every industry poses challenges, but video games have unique issues and opportunities. The following sections describe specific details of three consumer products that began as research projects inside Sony Computer Entertainment R&D.

2.1 EyeToy

EyeToy was a truly mass-market product, selling over 10 million units globally, but it began as a research project to investigate the types of experiences that would be possible by plugging a video camera (webcam) into a video game console. The powerful computation capabilities of consoles align well with what is necessary for real-time video processing and computer vision. EyeToy was essentially a standard webcam, but several design choices made it well suited for interactive experiences. For example, low latency was prioritized, so EyeToy compressed each frame individually in order to transfer over USB 1.1, rather than using an inter-frame video compression method such as MPEG. In addition, 60 frames/sec was the default output video rate to provide a smooth, high-speed tracking behavior.

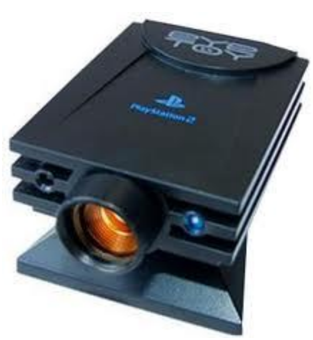

Figure 3. The EyeToy camera.

The goal of EyeToy was to introduce video games to a wider audience via an intuitive interface, and also to improve the overall interactive experience by directly involving the player visually. The biggest concern for EyeToy was the highly variable lighting conditions of people's homes. Unlike the office/laboratory environment, which is almost always well lit, the lighting available in many family/living rooms is much less consistent. But because players wanted to enjoy their experience, most were happy to add additional lights as necessary to brighten the scene while they played.

2.2 PlayStation Eye

The PlayStation Eye improved upon EyeToy based on feedback from both players and developers. It included a fixed-focus, low-distortion lens with two choices for field of view: standard or wide. To improve video quality, USB 2.0 high speed was used so the resolution could be quadrupled to 640x480 and video could be transferred uncompressed to avoid artifacts. And finally, the low-light sensitivity was greatly improved.

Though the PlayStation Eye was not as novel as EyeToy, its technological merits are confirmed by its wide adoption amongst computer vision researchers and hobbyists. Also, the high spec of the PlayStation Eye led to the creation of PlayStation Move.

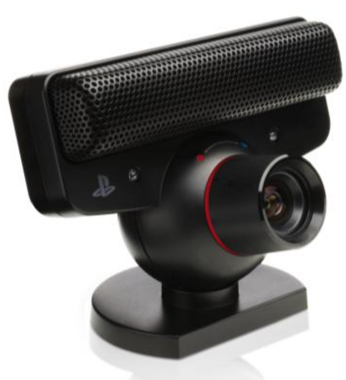

Figure 4. The PlayStation Eye camera.

2.3 PlayStation Move

The PlayStation Move is a one-handed motion controller for PlayStation 3 that incorporates a combination of optical and inertial sensing to provide complete six-degree-of-freedom (6DOF) tracking. Thus design addresses many of the issues discovered during the development EyeToy, combining the advantages of a camera-based interface with those of motion sensing and buttons. Game developers are provided with absolute position and orientation, linear and angular velocities/accelerations, and button state.

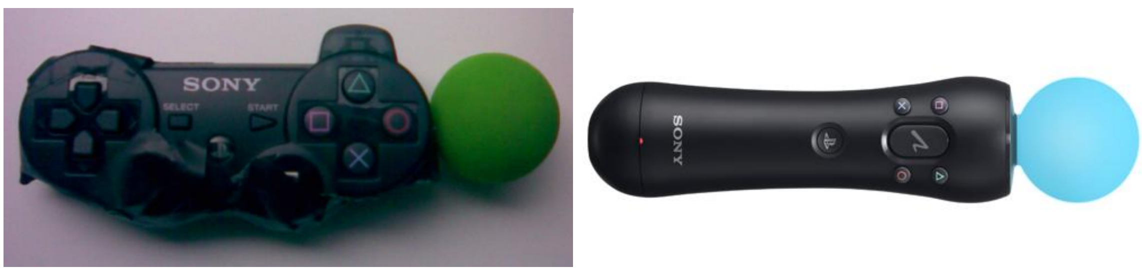

Figure 5. The PlayStation Move motion controller: initial prototype and final product.

Tracking the Move involves two major steps: image analysis and sensor fusion. Images from the PlayStation Eye are analyzed to locate the illuminated sphere that sits atop the controller (since the sphere is lit, it can be tracked even in complete darkness). Color segmentation is used to find the sphere in the image, and then a projected sphere model is fit to the image to extract the 3D position of the sphere. The results of the image analysis are fused with inertial sensor data from a 3-axis accelerometer and 3-axis gyroscope to provide the full state using a modified unscented Kalman filter. (LaViola, 2010)

Since its launch in 2010, PlayStation Move has sold over 13 million units globally and is supported by over 100 game titles.

LaViola, J. and Marks, R. (2010). "An Introduction to 3D Spatial Interaction with Video Game Motion Controllers". Course, *ACM SIGGRAPH 2010.*