FPGArcade:

Motivating the Study of Digital Hardware

Declining enrollments in engineering fields have led educators to look for new ways to motivate students. Video and computer games are often used to get students to spend time on subjects such as math and science that may not otherwise spark a young person's interest. Organizations such as DigiPen are developing projects to motivate middle and high school students to learn more about game development and 3D animation. Using game development as an education medium can prove difficult in early courses since game development requires knowledge of a variety of advanced topics such as digital design, I/O interfaces, real-time systems, graphics, and in some cases artificial intelligence. Tools that make game development easy for students tend to provide interfaces that abstract away many low-level details. The high level of abstraction implies that they are not as effective at helping students learn the underlying principles.

This paper presents the FPGArcade system that makes game development simple while still providing insightful details into low level concepts. Fledgling programmers can test the waters of the hardware/software interface without having to go through several courses in digital logic, computer architecture, and electric circuits. Using an inexpensive FPGA-based platform and free software from the Xilinx Corporation a programmer with some basic knowledge of C or C++ programming is able to create a simple computer game.

The FPGArcade is inspired by older gaming consoles. The model for the FPGAracade system is based upon the Nintendo Entertainment System's Picture Processing Unit (PPU). The PPU used tiles to take advantage of graphical redundancy thus reducing memory needed. The FPGArcade uses a tile-based design and defines a set of instruction codes used to interact with the video memory. These instruction codes are available as memory-mapped I/O. Programmers can access the instructions directly or call easy to use wrapper functions which can set the pixels and location of individual tiles. Tiles can also be set to fixed or movable, transparent or opaque, and solid or not. The system is intuitive and allows for a quick visual way to interact with hardware from high-level C code. The FPGArcade system also provides a joystick interface as part of the C library to provide ease of use for the student developer. The modular design of the system allows for the development of additional interface devices. These features create a fun, interactive, and educational system that can be used to encourage students in engineering and computer science to further their understanding of hardware.