A deployable training simulator using GPU warping

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ABSTRACT

Many simulators are large, complex systems with costly fiberglass or metal domes living permanently in fixed locations. Deploying more compact simulators which are easily transported into the field for onsite learning may be helpful. Reducing size, cost and weight keeps facility footprints compact and makes transportation, setup and disassembly faster and easier. These immersive multi-projector systems typically require warping and blending along with automatic alignment solutions to form a seamless image. The warp and blending process can be implemented in a number of places in the overall visual system. It is typically done directly in the projector hardware, or in an external 'warping box' between the IG and the projector, or as part of the IG software. We wished to explore a fourth option. Another technical issue for deployable simulators is how to rapidly develop compelling interactive content for training scenarios at relatively low cost. We describe how to apply software traditionally used more for visualization to a simple training simulation.

The research goal of our 'LowCostWarp' project was to develop a cost-effective prototype UAV simulator (Unmanned Aerial Vehicle). Warp and blending in the projector is limited to high-end projectors either with three-chip designs or specialized simulation specific LED-based single-chip designs. Proven robust software systems exist for warping and blending using machine-based computer vision approaches or manual warping by humans. We wished to explore a fourth *hybrid option* of warping and blending in the GPUs of NVIDIA graphics cards controlled by auto calibration software and imaging cameras.

Our approach to the warp/blend problem was to write code that interfaces with the NVIDIA warp and intensity API (NVAPI system) to extend its functionality, via control of the GPU. We effectively treated the GPU as a projector, warping and blending it as we always would. By making it mimic a projector we have a clear path for our existing auto calibration software to function seamlessly with this new technology. Our solution to the deployment problem was to design a lightweight, breakdown structure fitting entirely into an 8' cube envelope with an aluminum tubing structure. We also developed a novel, low-cost ellipsoidal curved screen to give a single UAV operator a wide mullion-free 140-degree field of view for better situational awareness and immersion than a laptop or monitor.

We assisted the operator in flying the UAV by providing low latency controls, binaural HRTF sound and eight-channel tactile feedback cues for the seat and feet to increase immersion. We built our own deployable half rack IG to show an oil refinery inspection scenario. This software was developed with an Agile Scrum rapid prototyping approach using remote login techniques to connect the teams in Ontario and California. The system was designed to accommodate a wheelchair for disabled veterans or users interested in flying a UAV or operating an ROV on ground or sea.