Smart displays

Environment-aware smart displays based on optical I/O-bricks using per-pixel light control

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Usually, computer and home entertainment screens are fixed in size, position, shape and perspective. Due to these limitations, the users are required to adapt to given setups, instead of the display systems continuously accommodating the users’ needs. Designing smart display systems, which can be activated, redirected and interacted with anytime and anywhere, is one of the core objectives of this project. The displays should also be aware of their environment and autonomously react to physical objects on the display surface.

The key ingredients of such pervasive display technologies are optical I/O-bricks consisting of projectors for image generation and cameras for calibration, 3D scene acquisition, tracking, and interaction with humans or sensor-enabled objects. A per-pixel light control mechanism enables simultaneous projection of patterns while displaying full color imagery, thus allowing imperceptible structured light approaches.

Micro-mirror light modulation

In DLP projectors, each displayed pixel is generated by a tiny micro-mirror, tilted towards the screen to project light and oriented towards an absorber to keep the pixel dark. Gradations of intensity values are created by flipping the mirror in a fast modulation sequence, while a synchronized filter wheel rotates in the optical path to generate colors.

Imperceptible patterns

By measuring the modulation pattern of a projector (left), one can carefully select the projected intensities (right) in order to control the appearance of each pixel during a pre-defined exposure time slot of a synchronized camera.

Projections on arbitrary surfaces

With the help of imperceptible patterns, algorithms can extract the 3D structure of a scene (left) and track a user (center) to create interactive environments supporting head parallax and undistorted projections on arbitrary surfaces (right).

Recalibration

Patterns allow a continuous dynamic recalibration of the system during runtime.

Freeform shapes

In settings with clutter and obstacles, displays of arbitrary shape use the limited display space more efficiently (left). The deformation is computed with a hyperbolic projection along the field lines of an electrostatic potential field (right).

Automatic adaptivity

The reflection properties of the projection surface can continuously be determined (top). Thus, collisions with objects or shadows in the environment can be avoided (bottom).