The Laser Sensing Display

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www.k2.t.u-tokyo.ac.jp/perception/SLP/

Laserinne

Summary

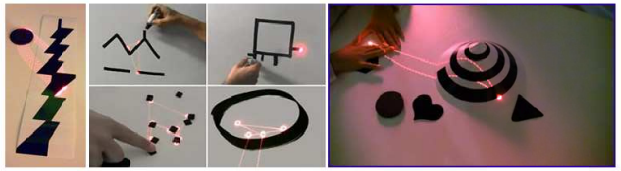
The goal of the project is to transform a whole ski slope into an interactive display, where (laser) graphics are drawn in response to the skiers' motion. Using laser projection, common in large scale audio visual shows, the graphics can be drawn from a single location onto an uneven surface in varying distance (something impossible to attain with standard projectors). Moreover, snow provides an excellent projection surface, giving high contrast imagery. Various interaction scenarios are being explored, including interaction with virtual skiers and virtual obstacles, annotation (competition scores, motion trails, speed display, etc), demarcation of safely perimeters and tracks for novices and skilled skiers, as well as real-time networked experiences (e.g. projection of skiers silhouettes from a ski slope in a different continent, etc). This is a **collaborative project between the University of Lapland, the Berlin University of the Arts and the University of Tokyo**, and the immediate goal is to showcase the system during the **2011 FIS Alpine Ski World Cup**.

The system combines standard camera tracking and camera-projector calibration (stereo pair or single camera for tracking skiers on a slope with known topography), as well as the laser sensing-display paradigm being studied in our lab - the latter enables real-time interaction with minimum feedback delay as well as easy deployment without the need of a calibration phase. All this facilitates numerous possible interaction scenarios ranging from informative to playful (for the audience and for the skiers themselves - including scores, secure perimeters, notification of dangerous obstacles in real time) to new forms of competitions and experiences on the slopes (and eventually on all kind of playgrounds regardless of the scale and shape - such as football or tennis, playgrounds, climbing walls, ping-pong tables, or just the street).

scoreLight: laser-based artificial synesthesia instrument

Summary

"scoreLight" is a prototype musical instrument capable of generating sound in real time from the lines of doodles as well as from the contours of three-dimensional objects nearby (hands, dancer's silhouette, architectural details, etc). There is no camera nor projector: a laser spot explores the shape as a pick-up head would search for sound over the surface of a vinyl record - with the significant difference that the groove is generated by the contours of the drawing itself. Sound is produced and modulated according to the curvature of the lines being followed, their angle with respect to the vertical as well as their color and contrast. Sound is also **spatialized** (see quadrophonic setup below); panning is controlled by the relative position of the tracking spots, their speed and acceleration. "scoreLight" implements gesture, shape and color-to-sound artificial **synesthesia**; abrupt changes in the direction of the lines produce trigger discrete sounds (percussion, glitches), thus creating a rhythmic base (the length of a closed path determines the overall tempo).



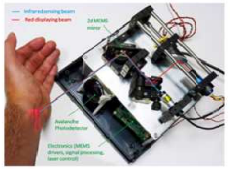
The hardware is very unique: since there is no camera nor projector (with pixellated sensors or light sources), tracking as well as motion can be extremely smooth and fluid. The light beam follows contours in the very same way a blind person uses a white cane to stick to a guidance route on the street. Details of this tracking technique can be found here. When using the system on a table (as in the image on the right), the laser power is less than half a milliwatt - half the power of a not very powerful laser pointer - and does not supposes any hazard. More powerful, multicolored laser sources can be used in order to "augment" (visually *and* with sound) facades of buildings tens of meters away - and then "read aloud" the city landcape.

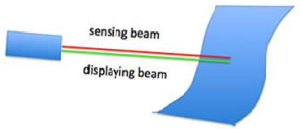
It is still too early to decide if this system can be effectively used as a musical instrument (has it enough expressivity? can we find a right balance between control and randomness?). However, it is interesting to note that "scoreLight", in its present form, already unveils an unexpected direction of (artistic?) research: the user does not really knows if he/she is painting or composing music. Indeed, the interrelation and (real-time) feedback between sound and visuals is so strong that one is tempted to coin a new term for the performance since it is not drawing nor is it playing (music), but both things at the same time... *drawplaying*?

The Smart Laser Projector (SLP): a cameraless 'sensing display'

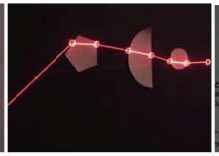
Summary

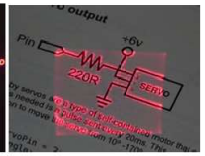
The "Smart Laser Projector" (SLP) is a modified laser-based projector capable of displaying graphics on a variety of non-prepared surfaces, while simultaneously using the beam (at the same or different wavelength or polarization) as a LIDAR probe gathering information about that surface position, orientation and shape, fine texture, spectral reflectance and even relative motion. It is therefore possible to synthesize an *artificial surface reflectance*, or to correct geometrical warp, all in real time and without the need of calibrating a camera and a projector. We have developed two prototypes, one working in raster-scan mode, and another in vector graphics mode. Our previous research on the Smart Laser Scanner, scoreLight and Sticky Light can be seen as special applications of the SLP in *vector-graphics mode*.





Applications of the SLP may include dermatology (enhancement of superficial veins or direct visualization of anomalous polarization induced by cancerous cells), non-destructive control (visualization of microscopic scratches, oily spots or mechanical stress), authentication (visualization of non-fluorescent UV or IR watermarks thanks to 'artificial fluorescence'), and in general all sort of augmented reality applications using any available surface for projection (tables, desktops, walls and floors, but also human skin, printed material and paintings, market products on a shelf, etc). Augmentation means here overlaying of alphanumeric data or icons over real object (for instance, human-readable price tags appearing under machine-readable barcodes), dynamic cueing (marking secure perimeters, indicate directions or highlighting dangerous obstacles) and line and contour enhancement for practical or aesthetic purposes.





The laser-based 'sensing display' paradigm presents a number of advantages with respect to the more classical "projector-camera' setup used in sensor-enhanced displays, among which:

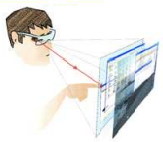
- no camera-projector calibration needed;
- very fast feedback (no image processing required);
- geometrical correction + color and contrast compensation possible;
- extremely large depth of field;
- variable resolution: the laser scanning step can be finer on regions of interest;
- simple and compact optical system: there is no 2d imaging optics, and hence no aberrations nor bulky optics;
- projection at very long distance in vector graphics mode ideal for outdoor interactive applications.

A MEMS based, compact SLP may eventually be embedded on clothes and used as a wearable display capable of transforming on-the-flight any surface near-by into a full interactive 'sensing display'.

Smart Laser Scanner (markerless laser tracking)

Summary

The problem of tracking hands and fingers on natural scenes has received much attention using passive acquisition vision systems and computationally intense image processing. We are currently studying a simple active tracking system using a laser diode (visible or invisible light), steering mirrors, and a single non-imaging photodetector. The system is capable of acquiring three dimensional coordinates in real time without the need of any image processing at all. **Essentially, it is a smart rangefinder scanner that instead of continuously scanning over the full field of view, restricts its scanning are to a very narrow window precisely the size of the target.**



Tracking of multiple targets is also possible without replicating any part of the system (targets are considered sequentially). Applications of a multiple target tracking system are countless. Such a configuration allows, for instance, multiple users to interact on the same virtual space; or a single user to control several virtual tools at the same time: resize windows and control information screens, as imagined in Spielberg's film "Minority Report" - but **without the need to wear special gloves nor markers**. A very interesting characteristic of the proposed 3D laser-based locator, is that **it also can be used as an output device**: indeed, the laser scanner can be used to **write information back to the user**, by projecting alphanumeric data onto any available surface, like the palm of the hand. This has been successfully demonstrated, without having to stop the tracking. Finally, hardware simplicity is such that using state-of-the-art Micro-Opto-Electro-Mechanical-System (MOEMS) technology, it should be possible to integrate the whole system on a single chip, making a versatile human-machine input/output interface for use in mobile computing devices.

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