Laboratory for Advanced Planning

and Simulation Project

A 3D geometry acquisition system under Linux: hardware specifications of camera.

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This document outlines specifications of the new 3D geometry acquisition system under Linux platform, detailing camera specifications.

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1 Project description

Aim of this work is the realization of an acquisition and 3D geometry reconstruction system. This package is the first stage of a Rapid Prototyping pipeline.

The RP pipeline is designed to acquire real objects by the 3D reconstruction system (or virtual object defined by CAD tools) into a virtual space where they can be analyzed in an augmented reality environment supporting high level and real time rendering interactive geometric modeling tools. The final geometry of objects can be automatically sent to the manufacturing device (rapid prototyping Stratasys Fused Deposition Modelling device www.stratasys.com).

This work is accomplished within the activities of the Laboratory for Advanced Planning and Simulation Project (LAPS www.crs4.it/~laps/) funded by the Ministry of Public Education (www.miur.it). The RP pipeline is realized in collaboration between the Geometric Modelling and Monte Carlo Simulation (GEMS) Area of CRS4 (www.crs4.it/~gems), the AILUN (www.ailun.it) and Proto21 (**space.tin.it/associazioni/maripani /english/p/proto21.htm**).

The final 3D acquisition and rapid prototyping system will be specifically tested in the medical field. The identified application is the 3D reconstruction of skulls of a patient for supporting augmented reality interaction to an interactive surgical-planning workstation.

The workstation is specifically designed for diagnosis and therapy of Refractory Epilepsy (RE), Parkinson Disease (PD) and Multiple Sclerosis (MS). This is a collaborative research project, co-funded by Hewlett Packard Italy, between:

- GEMS Area, CRS4, Italy;
- HP-LABS, Palo Alto, (CA) USA;
- AILUN, Nuoro, Italy;
- BIOLAB/DIST, University of Genoa, Italy;
- KAEMART Group Politechnic of Milan (www.kaemart.it), Italy;
- Neurology, Neuro-Surgery and Radiology Dept. University of Cagliari, Italy;

The basic idea of the project is that several neurological diseases face with a less fatalistic approach than 10-15 years ago. Most of the advantages in the treatment of these diseases come from new techniques neuroimage-dependent. Technological advances in medical imaging have enabled radiologists and neurologists to create image of the brain and its internal structures with unprecedented resolution and realism. However, the other side of this bonanza of technology arises from the difficulty for physicians to master and merge the results obtained with single facilities

(RM, CT, SPECT, EEG-3D-electrical-field-map, etc.) in a unifying clinical point of view eventually targeted to surgical solutions.

The workstation will be able to feature:

- low-cost fast interactive volume-rendering of neuro-images;
- fast interactive segmentation of false-colored 3-dimensional volume multi-modal neuro-images
- immersive geometric-volume-rendering using "virtual 3D" type head-tracked display and haptic interaction.

We want to study limits and possibilities of this technology, based on PC architecture (Linux). The end users of this product are: radiologists, neurologists and neuro-surgeons involved in the diagnosis and therapy of RE, PD and MS.

2 Camera specifications

Acquisition of images for 3D shape calculation will be done using a digital camera. The final device should be portable and could be installed in a laptop or in a desktop. The camera MUST not require inserting boards inside PC (i.e. frame-grabbers o Cameralink cards). So the camera must:

1. guarantee acquisition (at least) at 1024x768z10 bits with 20 Hz frequency (theoretical minimum bandwidth of 158Mbps).
2. support acquisition of two consecutive frames with a temporal distance not greater than 40ms
3. guarantee the possibility to increase acquisition frequency decreasing vertical sampling: final user has to be able to see the object in real time (2D visualization) with a resolution less than the one used for acquisition, and then decide “3D acquisition” (i.e. the double frames acquisition spaced of <40ms).

2.1 Output interface

Theoretical minimum bandwidth is 150Mbps, so we have 3 choices:

- PCI ;
- Firewire;
- USB 2.0 ;

All of them guarantee requested transfer rate but USB2.0 seems to be more suited for our purposes because:

1. we MUST be able to install acquisition system in a laptop;
2. larger bandwidth: USB2.0 theoretical transfer rate is about 480Mbps, 20% more than Firewire. With USB2.0 we could acquire images at 1280x1024x12bit with a sampling rate of about 30Hz;
3. better compatibility with Video4Linux2 to develop driver under Linux: Video4Linux2 is a driver abstraction layer defined in last generation linux kernels.

2.2 Synchronization of/with external events

Digital camera must be able to generate external events which reduce the logic of the acquisition system.

2.3 Software controlled temporal integration timings

The acquisition system works in two different modes:

1. real-time visualization (RT Mode)
2. 3D acquisition (3D mode)

During RT mode, light conditions are the same of environment; during 3D Mode, environment light contribution is reduced decreasing the integration time. To handle these two modes Camera has to give possibility of setting its electronic shutter via software.

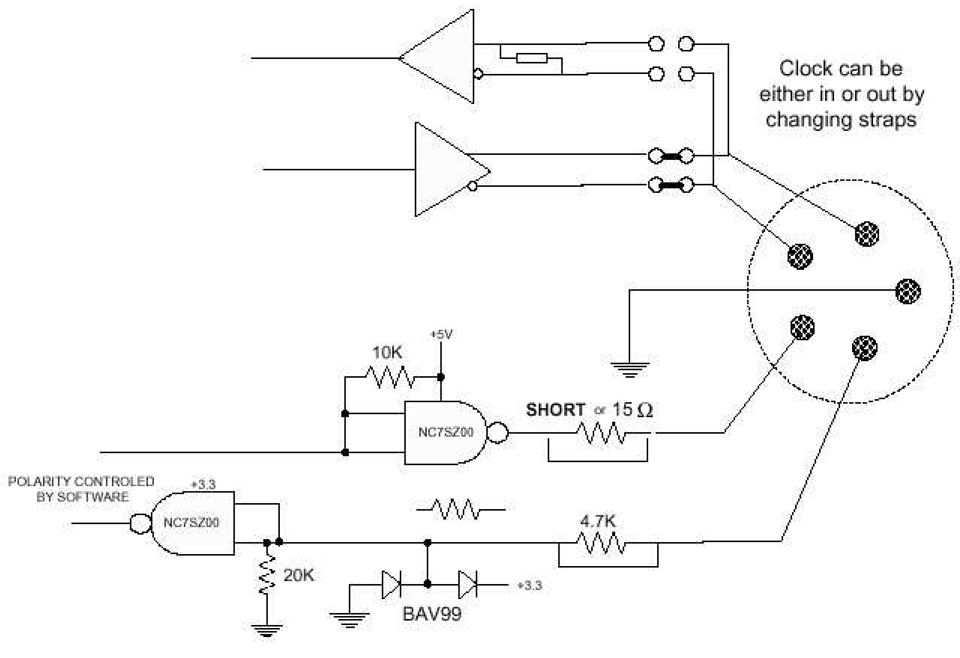
2.4 Hardware proposal: the Silicon Imaging 1280 USB Device

This camera seems to respond to all our specifications:

Acquisition modes: 1280x1024x12bit @20Hz. Moreover, it supports increasing frame-rate and decreasing vertical sampling frequency modalities.

USB 2.0 Output: Selected camera has a USB2.0 digital output

External events: it supports interaction with external events with this kind of circuit (taken from SI1280U datasheet)



Integration timings: it supports software handling of integration timings

3 Selected Bibliography

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