A Novel System to Evaluate Stereo Vision by Polarized Dual-Projection

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Background and Purpose

Stereo vision is an important component of human vision for depth estimation. In most sports a more precise and faster depth estimation results in higher athletic performance.

The purpose of our work is to develop a system to automatically evaluate **the performance of human stereo vision**.

Basics

Depth is simulated by displaying an object separately for each eye (stereo object)

Disparity denotes the offset within the stereo object

→ Depth impression in human stereo vision is controlled by disparity

Key Ideas

Performance of human stereo vision is based on two major issues

1. **Minimum disparity:** At which disparity is a correct depth estimation still possible?
2. **Resolving time:** How long does it take to resolve a certain disparity into a correct depth estimation?

→ Low measures indicate higher performance

Methods: System

Our developed *stereo vision test software framework* provides functionality to control the current projection system:

- Two LCD projectors with resolution of 1024×768
- Back projection
- Semi-transparent screen (2.50m×1.86m)
- Linearly polarized light for eye separation

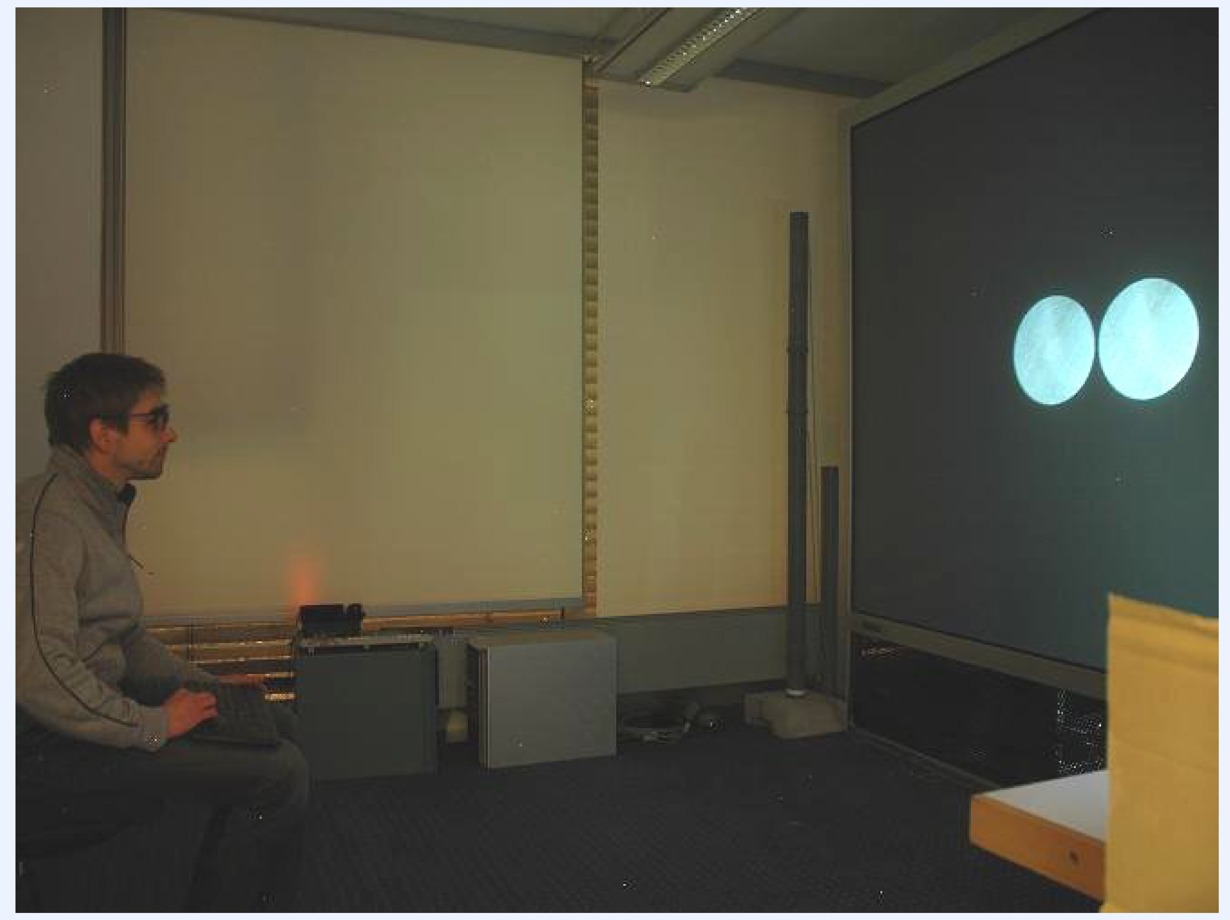

Figure 1: An observer performing a stereo vision test using the current projection system.

Methods: Stereo vision test framework

The system provides a fully configurable and interactive stereo vision framework. Basic test procedure:

- Two objects showing same size if no stereo vision is applied (Figure 2)
- One object with larger disparity (front object)
- Random front object in each iteration
- User decision by button press to identify perceived front object
- Output of test results graphically and as text file

A setup program allows the configuration of the stereo vision test. Configurable parameters:

- Target object type (disk, rectangle, sphere)
- Target object size
- Number and extent of disparity differences
- Number and extent of disparity bases
- Number of test iterations
- Disparity of one pixel in arc seconds
  → Required distance for observer will be displayed

Two performance parameters are measured

1. **Decision time** until user input is detected. It describes the *resolving time*.
2. **Number of correct decisions** for certain object sizes or disparity differences. It describes the *minimum disparity*.

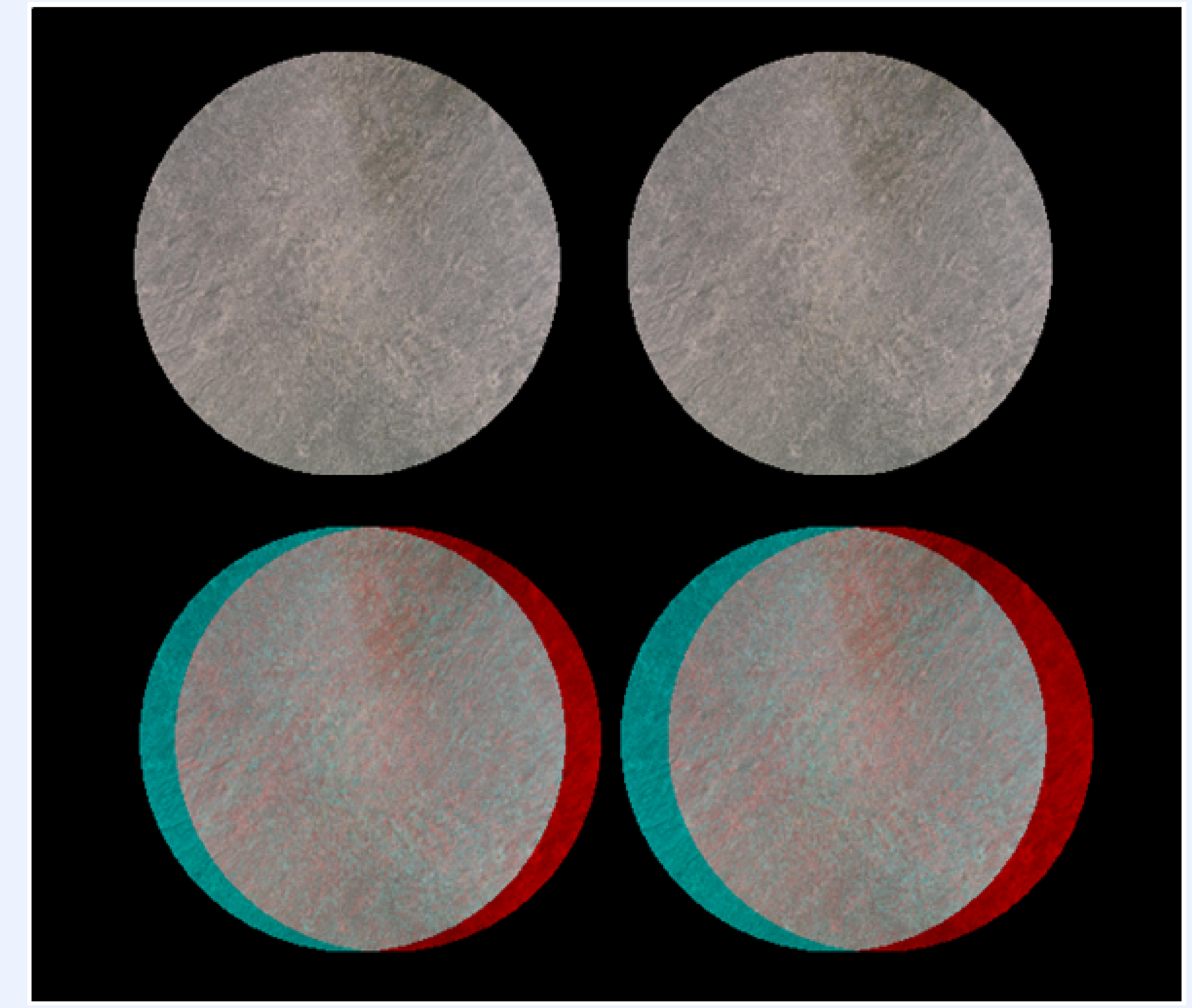

Figure 2: Example for two disks as target objects without (top) and with disparity (bottom, color coded; red: left eye, cyan: right eye) as they appear in the stereo vision test.

Methods: Preliminary study

The stereo vision test framework was configured to evaluate the disparity resolving times while the object sizes in arc seconds (") decrease.

- Disk diameters: 23940", 17990", 4711", 2943", 1137"
- Disparity differences: 975", 812", 650", 325", 162"
- 5 healthy male subjects (25-28 years)

For each disk diameter all disparity differences were shown. The average decision time for each diameter was stored. Only times for correct decisions were used.

Results

- **The decision times increase with decreasing disk sizes.**
- The decision times show a variation from 1266 ms to 4438 ms.
- **Figure 3 displays decision time differences** compared to the decision time for the largest disk size.
- The decision time differences of subject 5 differ significantly compared to the other subjects.
- All subjects achieved more than 50% correct decisions.

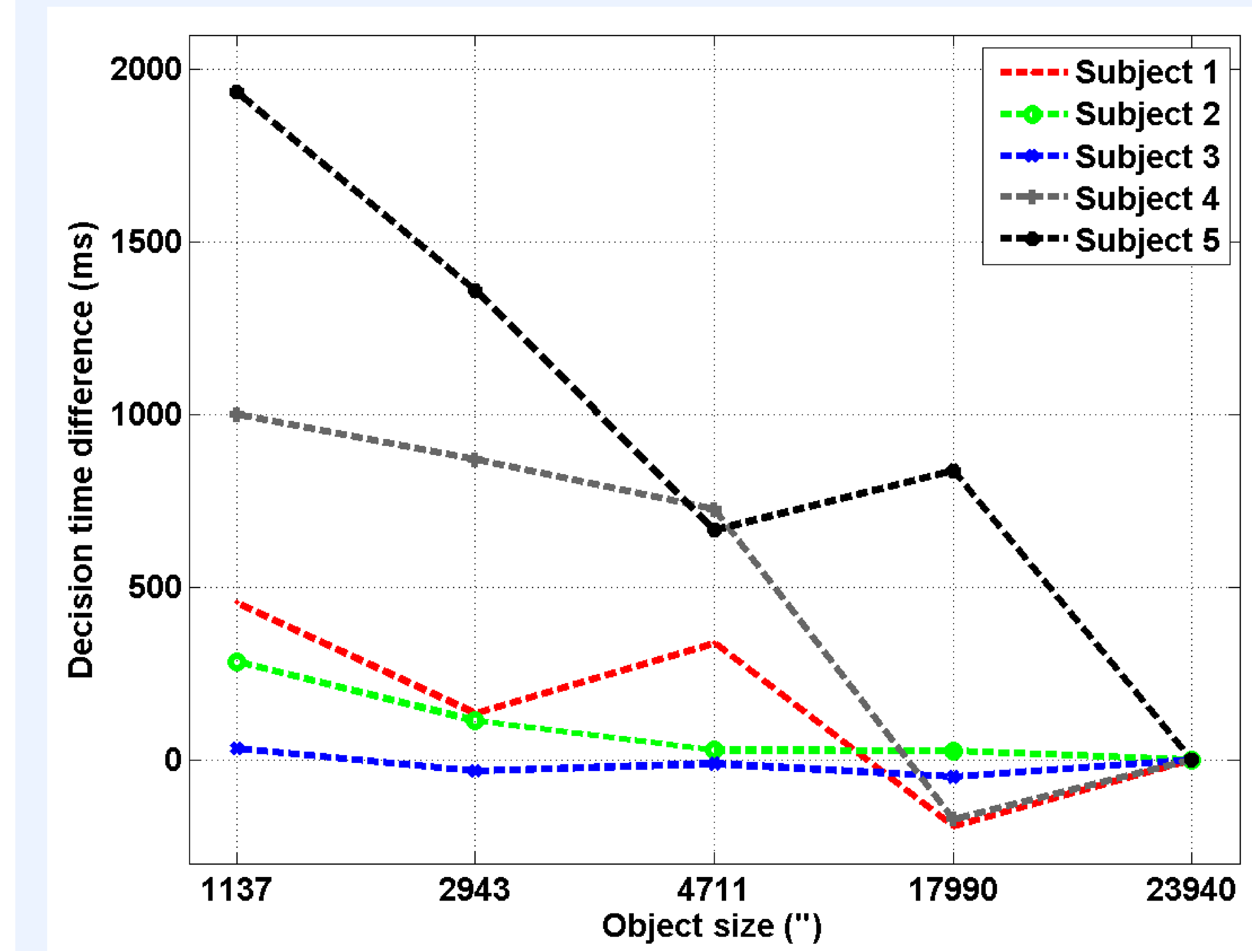

Figure 3: Decision time differences for each subject for specific disk sizes in arc seconds ("). The times are subtracted from the decision time for the largest disk size.

Conclusion

We developed a **comprehensive stereo vision test framework** embedded in a **polarized dual-projection system**. It is able to reliably measure the performance of human stereo vision with **arbitrary user defined tests**. The integration of **3D capable devices** and traditional 2D displays (**red-cyan color coded**) is already supported by the framework.

Outlook

The framework is currently extended to include **more target objects** to reduce the probability of a lucky guess. An **intuitive gesture control** that enables pointing onto targets is in progress to emphasize the sports character. The projection system is currently upgraded to higher resolution of **full HD (1920x1080)** to enable lower disparities. Future studies will present stereo vision performance as a function of the visual acuity.

Support

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Commercial Relationship

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