Scopemate: A Robotic Microscope

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ABSTRACT
Scopemate is a robotic microscope that tracks the user for inspection microscopy. The novel input device combines an optically augmented web-cam with a head tracker. A head tracker controls the inspection angle of a webcam fitted with appropriate microscope optics. This allows an operator the full use of their hands while intuitively looking at the work area from different perspectives.

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General terms: Design**,** Human Factors.

Keywords: Microscope, hand free, virtual window, head tracker.

INTRODUCTION
Inspection microscopes are used in industry and medicine to provide a magnified view of a region of interest. A typical application is soldering fine pitch components onto a printed circuit board. In this case, an operator peers through the microscope while manually operating delicate instruments in the field of view. To perform this sort of task effectively, the operator must have a good sense of the 3-D geometry of the work piece and the location of the tools. For this reason, most inspection microscopes are stereo – providing a 3-dimensional view.

A stereo inspection microscope certainly helps; however, a stereo view from a single angle has limitations. Occlusions can make critical features impossible to see without repositioning the work piece. Additionally, many people suffer from poor depth perception due to vision problems in one eye, or problems with eye-to-eye coordination [7]. In normal vision tasks, people work around these limitations by using motion parallax [7]. They view the scene from different perspectives. This helps reveal the 3-D structure.

One of the most popular inspection microscopes is the Mantis from Vision Engineering [8]. This stereo inspection microscope features "expanded-pupil" technology – there are no traditional eyepieces. Instead, the images are formed over a relatively large area. Thus, precision alignment of the eyes to the microscope is not required. A major benefit of this system is that a user can make slight head movements, observing the microscopic scene from slightly different angles. In essence, it allows a user to "look around" a scene while keeping their hands free. This greatly improves 3-D understanding.

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In recent years, the low cost of high quality cameras and displays has raised the possibility of replacing optical inspection systems with electronic ones. Unlike a traditional optical microscope, the display can be large, and placed in the most ergonomic position, independent of the camera. As stereo displays become more ubiquitous, we predict that they will be integrated into inspection systems. However, even if electronic inspection systems add stereoscopic display, they will still be missing a critical feature of the Mantis microscopes – there is no way to "look around" or to benefit from motion parallax.

In this work, we describe a prototype tracking inspection microscope that allows a user to "look around" a region of interest. Our first robotic microscope camera allows users to view a scene from different angles. A second camera tracks the viewing position of the user's head relative to the display, see figure 1.

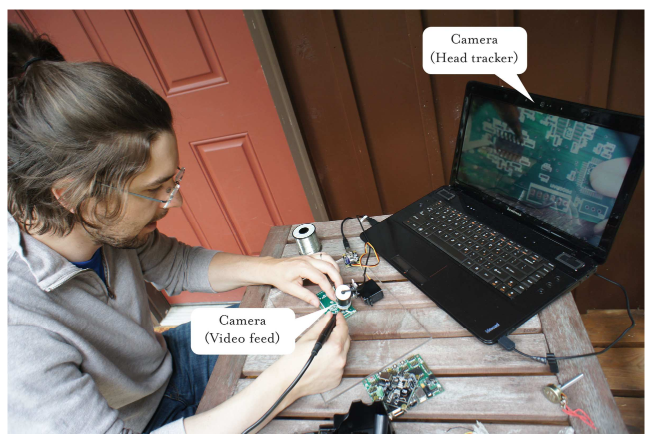

Figure 1. Our tracking inspection microscope setup.

This information is used to automatically position the robotic microscope camera to a corresponding viewing position relative to head position. The result is an intuitive, hands-free, microscopic inspection system that allows the user to "look around".

RELATED WORK
Hand free interfaces have been researched for more than a decade exploring solutions for people with disabilities who are unable to use traditional input devices [5], [4], [3]. Users mainly rely on head pointing [4] to control a cursor location or control a voice-driven application [3]. Whereas,

previous research mentions the potential use of hands free interface during hands-busy situations, the systems typically solve problems in the assisted devices and physical disability space [5], [4], [3]. We propose to explore a hand-free system for hand-busy industrial situations, such as the use of a soldering iron on a circuit board.

Virtual Windows provide a hands-free, natural user interface for examining a remote location. The result is similar to a window allowing exploration of remote scenes [1] or merging scenes [2] rather than a flat screen showing moving pictures. A head tracker determines the relationship between the viewer and the display, and automatically provides the correct perspective. For instance, a remote camera can move forward when a local user approaches a display so that the approach is amplified by a remote person's expanding image accompanied by motion parallax. This creates the illusion of looking through a window.

This same concept can be applied to many different applications where one wishes to "look around". We can look around remote locations, look at vastly different scales, or look around data. With the democratization of motion and head trackers with breakthrough interfaces such as the Kinect device, we expect an explosion of useful applications that rely on motion tracking as an input.

IMPLEMENTATION

The correlation between head movements and the viewpoint from a microscope allows users to adjust the view of the inspected materials while soldering. We informally observed that in existing microscope setups, the user has to interrupt her soldering to reposition the workpiece and to get a better viewing angle. In our scenario, the user continuously solders while moving the head to automatically reposition the camera providing important depth cues and peering around obstructions.

System

A monitor displays the microscope view. As a user looks at the display from different angles, her relative head position is tracked, and used to drive an actuated microscope. To display the video feed, we use a regular web camera with an attached magnifying lens. To track the operator, we use the camera already available in most laptops. To control the rotation of the camera along one main axis, we connected one robotic servo motor to a servo controller that sends and receives data to and from our software. The servo motor is affixed to a rotation arm to suspend the camera over the workpiece, see figure 2. To implement this prototype, we used the Max/Msp/Jitter environment to program our software. We created the head tracker integrating on the computer vision libraries cv.jit. We track head motion in the X, Y and Z axes. In our final implementation, we choose to only control the X axis. The input data from the head motions is scaled and mapped to the servo motors rotation. The X axis is mapped to servo 1.

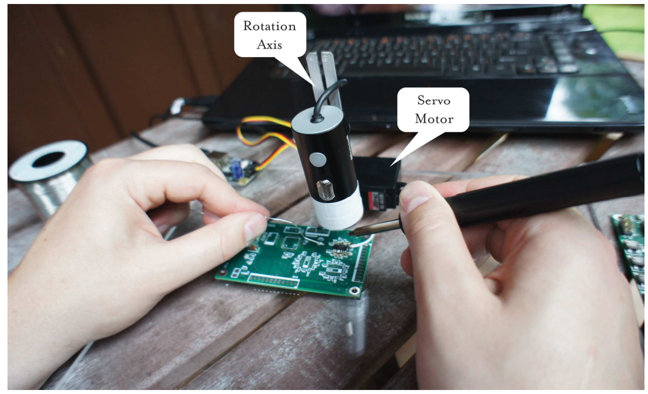

Figure 2. The hardware components in Scopemate.

CONCLUSIONS and FUTURE WORK

Our tracking inspection microscope could upgrade current high-end microscopes or act as an affordable interface for anyone who needs multiple views while soldering their electronic components. We found that one single head motion to control the interface along one axis, for instance looking right and left, up and down or to zoom in and out of the viewpoint, is a spontaneous way for the user to interact with the device. As soon as we incorporated multiple axes of motions to control multiple visual perspectives, for instance, controlling the interface right and left then up and down, or zooming in and out of the scene controlling the panning, the interface appeared less intuitive. It indeed required the user to iterate back and forth before working with the right angle of view. However a future empirical user study is needed to support our claims and find the balance between actuated view functionality and ease-of-use.

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