1185540 Ontario Inc.
(Formerly Absolute Video Theatre)

SCIENTIFIC RESEARCH AND EXPERIMENTAL DEVELOPMENT

Fiscal Year Ending July 31st, 2006

Schedule 32: **Background and Project Information**

BACKGROUND INFORMATION 1

A. TECHNICAL CONTACT PERSON 1
B. COMPANY BACKGROUND 1

PROJECT SUMMARY INFORMATION 2

A. LIST OF PROJECTS 2
Development of a Virtual Presence via Videoconference 2
B. TECHNICAL PERSONNEL 2

DETAILED PROJECT DESCRIPTION 3

(P1) PROJECT 1: DEVELOPMENT OF A VIRTUAL PRESENCE VIA VIDEOCONFERENCE 3

PROJECT BACKGROUND 3
A. TECHNOLOGICAL OBJECTIVES 3
B. TECHNOLOGY OR KNOWLEDGE BASE LEVEL 4
C. TECHNOLOGICAL ADVANCEMENT 4
D. SYSTEMATIC INVESTIGATION 5
E. TECHNICAL DOCUMENTATION 8

Background Information

A. Technical Contact Person

The person to contact for technical questions regarding this submission is Mark Corlett at 416-948-2127.

B. Company Background

AVT.ca sells, installs and maintains audio-visual systems for Canadian corporate and industrial users. The company has been involved with the audio-visual industry since 1988 and currently has 5 employees.

PROJECT SUMMARY INFORMATION

A. List of Projects

CODE	PROJECT NAME	START DATE	END DATE	LABOUR
V1	Development of a Virtual Presence via Videoconference	Sept 2006	Dec 2006	$7,332

B. Technical Personnel

Mark Corlett:
Mark is the CEO of 1185540 On. Inc (o/a AVT.ca) and plays a large role in the day-to-day development of the company. He has an Electronics degree from Sheridan College as well as an Audio degree from the OIART. Mark has extensive experience with audio/video systems.

Al Bourke:
Al is the VP and Senior Engineer with AVT.ca. Al attended Humber College for theatre technology. Since college, Al has distinguished himself within the theatre community and has taught college level courses on lighting technology at Ryerson. Al has extensive CAD and programming abilities.

Jeremy Bui:
Jeremy Bui is the Project Manager at AVT.ca. He has completed 9/10 of his BSc with Ryerson Polytechnic Institute and had been employed in the audio video field for his entire working life.

DETAILED PROJECT DESCRIPTION

(P1) PROJECT 1: Development of a Virtual Presence via Videoconference

Project Background

A challenging element of videoconferencing relates to eye contact, or more specifically, the complete lack of eye contact. Currently, all videoconference systems incorporate cameras that are meant to reside above, below, or beside the far-site display image. Because the camera is physically located away from the distant party, the camera typically captures the side, the top, or the bottom of the participant's head. Thus the camera location "breaks" eye contact, rendering the videoconference less user immersive.

We initiated this project with the intent of creating a new videoconferencing system that is able to maintain eye contact with the distant party, something that is not currently available on the market to the best of our knowledge.

A. Technological Objectives

The challenge at hand was to advance the operational method by which videoconferencing cameras capture the meeting participants to create a better link between the near-end parties and the far-end parties.
The specific objectives of this project were:

- Keeping the video camera's location coincident with the video image on the projection screen by incorporating a 2-D moveable robotic arm
- To minimize the physical obstruction of the camera on the video screen by pre-programming the robotic arm to move and focus the camera on whoever is speaking in the boardroom
- Design a robotic arm that is no wider than 5 ¼", yet rigid enough to be able to hold a camera at a distance of 24" from the anchor point, and not flex more than ½"
- The robotic arm and all mechanical components must fit into a total area not exceeding 16" x 6"
- Ensure that the robotic arm and projection screen do not interfere with one another by incorporating an automated logic system that will prevent the video conferencing components from damaging each other

B. Technology or Knowledge Base Level

After conducting extensive research into the capabilities of current videoconferencing equipment, we concluded that there was not any video conferencing system available on the market that was able to create an effective virtual presence for both parties. By incorporating a video camera onto a 2-D moveable robotic arm in front of a video screen, we believed our system would be successful. After conducting extensive research, we discovered that it is possible for the subconscious mind to account for having one eye blocked by the video camera, and still be able to effectively view the image behind the camera with the other eye. This would give the illusion that the participant was making eye contact with the far distant image. This information was promising enough for us to move forward with the project, however we were still faced with the following uncertainties:

- Would we be able to keep the video camera's location coincident with the distant video image by incorporating a 2-D moveable robotic arm?
- How could we minimize the physical obstruction of the camera on the video screen as to not adversely affect the near end video experience?
- How could we design the robotic arm so that it is no wider than 5 1/4" (in the stowed position), yet is rigid enough to be able to withstand warpage and bending when fully extended 24"?
- Is it possible to incorporate the pan-tilt-zoom camera, the robotic arm and all of the mechanical components into a small footprint which is a 6" deep and 16" wide?
- How can we ensure that the camera will be oriented in a predictable way, such that it will have the same visual effect for any person speaking in the boardroom?
- How will we interrelate all of the components of the system to ensure they are automated, and will not cause damage to one another if one of the components is moving?

C. Technological Advancement

The technological advancement sought was the development of a Virtual Presence System to be used for video conferencing. We were able to successfully meet all of our objectives set out for the fiscal year which included:

- Developed a 2-D movable robotic arm which allowed the positioning of the video camera to remain coincident with the projected video image
- For optimal robotic arm operation, concluded that brass gears are more resistant to wearing out than nylon, gear ratios must be set at 150:1 to ensure the arm movement is within 1/8" tolerance, and motor horsepower must be at least 1/3 hp to be able to move the load of all components

- Developed a reliable and repeatable system that had an increased sense of connection to both the near and far end users by creating the illusion of continuous eye contact between both parties
- Designed a robotic arm that is minimized in size (5 ¼″ wide, 24″ long), yet is rigid enough to flex no more than ½″ when fully extended
- Successfully met all of the size constraints by incorporating all of the videoconferencing components into a 16″ x 6″ area
- Developed an automated system using sensors and feedback logic that ensured the robotic arm and projection screen do not interfere with one another during normal operation

D. Systematic Investigation

Fiscal 2006 Experimentation

After analyzing the limitations of currently available videoconferencing equipment to maintain eye contact between both parties, we set out to develop our own user immersive system. We hypothesized that if we located a camera near the centre of the image on the view screen, it would provide the illusion of continuous eye contact to the users. Normally, cameras are oriented in such a way that they do not focus on the eyes, but rather are at an angle, and capture the side of a participants head or their face at an odd angle.

Experimenting with Projection Image and Camera Orientation

We began by researching methodologies that would allow the camera to be placed in the centre of the far end image screen, yet not detract with the far-end video image. First we needed to determine what size of the distant party is required in order to get the sense that the distant party is 'present' in the room. We knew that the image had to be large enough to satisfy the viewing requirements of the most distant participants in the boardroom. By creating several mathematical models of the room geometry and participant orientation, we were able to conclude that the most distant viewer had to be sitting within 6 times the image height. We determined that a 100″ diagonal screen would be able to give the necessary specifications required.

The next challenge to focus on was determining the optimal camera orientation. We found the smallest available pan-tilt-zoom camera, and using the camera as a model we began experimentation with finding the optimal position for it. It was necessary for the camera to be placed in a position so that it would not interfere with the projection and cause a shadow onto the screen, as well as be oriented in such a manner that it only interfered with one of the participant's eyes. We created 3-D CAD drawings to determine the optimal camera location and tested the results. Our first experiment located the camera 1 foot away from the view screen at eye level, and although the camera did not interfere with the projection, it sufficiently blocked the image for the participant that they were not able to see the person talking to them on the screen. This result was unacceptable and so we proceeded to test a further distance. Upon testing a distance of three feet, we realized that the camera would be too far for a practical motor mechanism to be installed. It would be exceedingly difficult if not impossible for the motor to position the camera to within 1/8" of its required location due to the inherent gear limitations, and the combined weight of the arm and camera would cause significant flex. Next we tested a distance of 2 feet from the view screen at eye level. These results were the most favourable as the camera did not block the projection, and only blocked the image in one of the participant's eyes. For example, the participant could only see the image with their right eye, and the left eye saw the camera. This resulted in the illusion that the participant was making eye contact with the far distant image. At the same time, the participant's view of the image was not obstructed as the subconscious mind has an eye block correlation mechanism that accounted for the disturbance from the camera and did not focus on it.

We could now proceed to designing a mechanical system in an attempt to satisfy the remainder of our objectives.

Prototype Development

Since there was no available off the shelf motor and robotic arm that met our size and operation constraints, we decided to build the system ourselves. The first step was to design the arm itself. We were restricted to designing the robotic arm out of wood due to our client's request, and began testing ash and pine wood. The arm needed to be thin enough to fit in the housing, yet rigid enough to support its weight and that of the camera from a single anchorage point at the end of the board. To simulate a worst case scenario and incorporate a safety factor, we decided to place a 5 pound weight at the end of the board and measure the flex. Testing revealed that ash and pine wood were bending over 1" when full extended from the test bench. We proceeded to experiment with Oakwood and found that the arm flexed less than ½" which was well within acceptable tolerances.

Next we focused our attention on the motor and the gears. For our videoconferencing system to be successful, the camera had to be positioned to within 1/8" of its pre-programmed position. Originally we hypothesised that a gear ratio of 90:1 would satisfy this objective, but upon testing we found that the arm movement was too rough and fast to be able to accurately position the arm. We increased the gear ratio to 150:1 and the results were promising as the arm was able to position itself to within 1/8" of the required position.

An unexpected problem occurred however with the motors. The original motor that we were using was 1/4 horsepower, and we found that over time it was beginning to burn out and break down. We hypothesized that the weight of the board and camera was too much of a load for the motor to handle, so we integrated a 1/3 horsepower motor. We hoped that this motor would be able to cope with the load of the robotic arm without burning out, because we could not incorporate anything stronger as it would take up too much space. To date the 1/3 horsepower motor is operating without fault and we hope that the problem has been solved.

Further along in the testing phase, we encountered another problem. The gears we were using were wearing out after repeated use. We were originally working with two nylon gear bushings. We wanted to avoid changing the gear ratios in the mechanism because we had reached our 1/8" tolerance specification. We therefore focused our attention on the gears themselves, and hypothesized that redeveloping the gears into a durable and wear resistant construction would be able to better cope with the weight of the arm. Experimentation with the gear composition led us to utilize brass equivalents to our nylon units. The brass gears are much more wear resistant and maintained our 1/8" tolerance specification. To date the gears have not needed to be replaced since implementation.

Robotic Arm Operation

We needed to ensure that the camera arm would not interfere with the sliding panels and the screen causing damage. When the camera is deployed and positioned in front of the projection screen, it must be aware of its location with respect to the screen. If for example the camera arm was retracted after the screen was in place, the robotic arm would damage itself and would damage the screen as well. Thus, we found that we needed to incorporate sensors in the logic controller which would provide consistent, reliable status reports as to the location of the components. These sensors fed into a "Crestron digital I/O," which would then feed a software truth-table for safety evaluation.

We started out with conventional "normally closed" security switches to derive position logic and used a variety of sensors for the screen. The results of using these switches were unacceptable as they provided intermittent feedback when the arm was in close proximity to the switch. In addition to this, their visual footprint detracted from the overall video conferencing experience. We hypothesized that a security sensor paired with a very small and powerful Earth Magnet would yield better results. During testing we found that this solution worked perfectly and there were no reportable issues. The switches were installed on the two sliding doors, the camera arm, and on screen when it was stowed.

In addition to the logic sensors for safety, we also incorporated two other safety measures. The first measure was a “motor time-out” on the control system, and the second was a 120V leaf switch on the camera arm. The deployment time of the arm was measured to be two seconds. Thus, we pulsed the power to the motor for three seconds, hypothesizing that the motor would “time out” if there was a problem of any sort after the three second “on” pulse. The second safety measure was the 120V switches which were positioned at the “stop” points on the arm. They will prevent the arm from over extending its intended operational range. The project was concluded in December of 2006, and we do not have any outstanding issues to address.

Fiscal 2006Year-End Status

The project is complete.

E. Technical Documentation

- Project drawings and notes