

**MONASH UNIVERSITY
REHABILITATION TECHNOLOGY
RESEARCH UNIT**

"STUMP-CAM"

**BY
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INTRODUCTION:

In the field of Prosthetics and Orthotics there have been many technological breakthroughs, so as to increase the efficiency of the Prosthetist-Orthotist and to provide the best possible prosthetic-orthotic devices to the patients, thus enhancing their quality of life.

Some examples of these are as follows:
the fatigue tester for leg prostheses,
modular componentry and
dynamic transparent check sockets.

The concept of transparent check sockets for below-knee(BK) prostheses is used in the project in which I have undertaken. "**STUMP-CAM**" is basically that, a camera which is mounted onto the prosthesis, looking through the transparent check socket and onto the stump.

Why do we want to look at the stump?

What do we see when we are observing the stump?

Why use a camera?

What is all this telling us?

These are the prime questions which are of great importance to the project.

Why do we want to look at the stump?

We want to look at the stump to monitor various pressure points during the GAIT cycle. This is so as to evaluate whether or not the region of pressure is excessive enough to cause discomfort to the patient.

What do we see when we are observing the stump?

Skin can act as a very sensitive pressure transducer. When pressure is applied onto the skin, it changes colour . Hence, the pressure distribution on the stump can be seen.

Why use a camera?

Conventional camera and video recording equipment have been used to record patients while they are walking. But the problem has been that the camera cannot focus close into the socket without picture distortion or being in the way of the patient while walking.

What is all this telling us?

What we want to do, is to bring all of these aspects together and turn it into a feasible clinical and diagnostic tool

Therefore, by finding the appropriate specialised camera which can be mounted on to the prosthesis, we hope to be able to monitor patients while they are walking. Hopefully, the camera will be able to detect various pressure changes during GAIT and if they are causing a patient any discomfort, then the Prosthetist-Orthotist can take back the socket and modify it to fit the patient comfortably.

AIM:

In this project we want to test out the possibility of monitoring any pressure variations occurring on the stump during different stages of GAIT by looking at the skin-colour changes.

METHOD:

Firstly, what had to be done was to make a list of all the criteria and specifications concerned with the project.

SPECIFICATIONS

The general criteria for this project were that the camera and mounting be as small and lightweight as possible. This is so they do not interfere with the patient's normal walking pattern. Thus the leg would be monitored through different stages of GAIT, as if the patient was walking naturally.

The criteria for the camera were as follows:

- small and lightweight.
- be able to monitor anterior, posterior and lateral views.
(there would be difficulties in monitoring the medial view)
- the ability to focus into various regions of the stump.
- use some form of telemetry to make the system as portable as possible.
- COST
- camera compatibility with available video recording/editing equipment.
- find other possibilities if camera/video equipment are not compatible.

[JVC SVHS video recording equipment would be used]

The criteria for the mounting were as follows:

- As far as the mounting was concerned, it should be as strong and lightweight as possible.

-Should be constructed in such a way so as to be able to rotate around the prosthesis and move up or down the pylon.

After looking at all of these specifications, we made enquires about various types of cameras. We asked for demonstrations, brochures, data sheets and also for actual cameras to borrow so that we could run actual tests with patients and record some footage. In this way we would be able to best evaluate which type of camera would be most suitable for our purposes. The following is a list of the different types of cameras which we obtained information on with some commentry about each one and their suppliers.

CAMERAS AND THEIR SPECIFICATIONS:

SONY XC-999P (Refer to Appendix A on page 21)

COST:	\$4380 (5m cable)
HORIZONTAL RESOLUTION:	460 TV lines
DIMENSIONS:	22mm×22mm×120mm
WEIGHT:	110g (with lens)
LIGHTING REQUIREMENTS:	auto iris
POWER REQUIREMENTS:	DC12 ±10%

COMMENTS:

We were able to borrow the camera for a few days with the 12mm and 3mm lenses and test it out and recorded some footage. Its picture was very clear. Relative to some of the other cameras its price was average.

SUPPLIER:

Videocraft
17 Royton Street,
East Burwood 3151, Victoria.
Fax: (03) 803-6401 Tel: (03) 803-6699
James Taylor (Technical Sales)

ELMO EM-102

COST:	\$5041
HORIZONTAL RESOLUTION:	360 TV lines
DIMENSIONS:	φ17.5mm×54.5mm
WEIGHT:	35g (with lens)
LIGHTING REQUIREMENTS:	full iris control
POWER REQUIREMENTS:	AC220V-240V

COMMENTS:

Although it is quite small and light in weight, its picture quality is not as good relative to most of the other cameras. It is also one of the most expensive ones. All relevant information can be found in the data sheets provided.

SUPPLIER:

IBS AUDIO VISUAL

958 Canterbury Road,

Box Hill 3128, Victoria.

Fax: (03) 890-5229 Tel: (03) 890-5220

Ian Ward

ELMO MP481 (Refer to Appendix B on page 22)

COST:	\$5172
HORIZONTAL RESOLUTION:	460 TV lines
DIMENSIONS:	φ17.5mm×54.5mm
WEIGHT:	26g (with lens)
LIGHTING REQUIREMENTS:	white balance
POWER REQUIREMENTS:	DC12V ±0.5V

COMMENTS:

Quite small also, with similar quality of resolution to the SONY camera mentioned earlier. But at the same token, more expensive than all of the other cameras mentioned in this report.

SUPPLIER:

COLLINS VIDEO COMMUNICATIONS

P.O. Box 61,

Ringwood 3134, Victoria.

Fax/Tel:(03) 870-3079 Mobile: 018 535 458

Ron Collins

AND

SCIENTIFIC INSTRUMENT MANUFACTURE & REPAIR CO.

663 Chapel Street,

South Yarra 3141, Victoria.

Fax: (03) 827-7248 Tel:(03) 823-1533

Jim O'Flynn Mobile: 018 039 603

PULNIX PACK-CAM

COST:	\$1880-\$2225
HORIZONTAL RESOLUTION:	450 TV lines
DIMENSIONS:	φ21mm×50mm×80mm
WEIGHT:	100g (lens and board)
LIGHTING REQUIREMENTS:	auto iris
POWER REQUIREMENTS:	TO BE ADVISED

COMMENTS:

Properly named the Pulnix Pack-Cam Board colour camera, this has also got high resolution and is relatively inexpensive. It has an advantage ,in that it can run on a 12V DC battery.

SUPPLIER:

COLLINS VIDEO COMMUNICATIONS
P.O. Box 61,
Ringwood 3134, Victoria.
Fax/Tel:(03) 870-3079 Mobile: 018 535 458
Ron Collins

PULNIX TMC6i

COST:	\$1875
HORIZONTAL RESOLUTION:	450 TV lines
DIMENSIONS:	42mm×39mm×133mm
WEIGHT:	235g (with lens)
LIGHTING REQUIREMENTS:	auto iris
POWER REQUIREMENTS:	12VDC

COMMENTS:

Again, this camera can obtain high resolution and it can also run on a 12V DC battery. Its disadvantage is that it is relatively heavy.

SUPPLIER:

COLLINS VIDEO COMMUNICATIONS

P.O. Box 61,

Ringwood 3134, Victoria.

Fax/Tel:(03) 870-3079 Mobile: 018 535 458

Ron Collins

PULNIX TM-6BE

COST:	\$1155
HORIZONTAL RESOLUTION:	450 TV lines
DIMENSIONS:	≈75mm×75mm(cct board)
WEIGHT:	100g (with lens)
LIGHTING REQUIREMENTS:	mini auto iris or optical block
POWER REQUIREMENTS:	TO BE ADVISED

COMMENTS:

With its proper name being the Pulnix Mini Card Cam System TMC-6BE, the camera (being only a circuit (cct) board and lens) acquires high resolution, as with the others, and is inexpensive. It has some more advantages, in that, one can custom build a housing for the circuit (cct) board and lens to suit the application it is required for. Also, the camera can perform telemetrically fairly easily by using a UT-66 video sender (UHF, Ch. 36). So, this and the camera are connected to a 12V DC battery, hence the patient can wear the system on a belt pack. We borrowed the system (with optical (CS) block) and tested it out, but when the TV received the signal, we could not obtain a clear picture, so we recorded some footage by connecting the camera to AC power and the mixer. Another point was that it was quite sensitive to the lighting of the room.

SUPPLIER:

COLLINS VIDEO COMMUNICATIONS

P.O. Box 61,

Ringwood 3134, Victoria.

Fax/Tel: (03) 870-3079 Mobile: 018 535 458

Ron Collins

PANASONIC WV-KS152

COST:	\$3932 (2m cable)
HORIZONTAL RESOLUTION:	430 TV lines
DIMENSIONS:	φ17mm×37.8mm
WEIGHT:	28g (with lens)
LIGHTING REQUIREMENTS:	electronic light control
POWER REQUIREMENTS:	12V DC

COMMENTS:

Very small, lightweight, fairly high resolution, but with an average pricetag nonetheless. It is quite similar to the ELMO MP481 camera, just a little smaller in size.

SUPPLIER:

GEC AUSTRALIA LTD.

GEC VIDEO SYSTEMS DIVISION

152 Highbury Road,

Burwood 3125, Victoria.

Fax: (03) 245-3222 Tel: (03) 245-3200

Toll Free 008 011 053

Graeme Burbidge (Victoria State Manager)

OR

John McKenna (Senior Sales Engineer)

Mobile: 018 543 734

PANASONIC WV-KS202

COST:	\$3474 (without cable)
HORIZONTAL RESOLUTION:	330 TV lines
DIMENSIONS:	φ12mm×35mm
WEIGHT:	19g (with lens)
LIGHTING REQUIREMENTS:	manual iris (in 6mm lens)
POWER REQUIREMENTS:	12V DC

COMMENTS:

Smaller still, extremely lightweight and similar in price with the previous model. But the resolution is not as good with some of the other cameras.

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Graeme Burbidge (Victoria State Manager)

OR

John McKenna (Senior Sales Engineer)

Mobile: 018 543 734

PANASONIC GP-KS252

COST:	TO BE ADVISED
HORIZONTAL RESOLUTION:	430 TV lines
DIMENSIONS:	φ12mm×35mm
WEIGHT:	19g (with lens)
LIGHTING REQUIREMENTS:	electronic light control
POWER REQUIREMENTS:	12V DC

COMMENTS:

As with the previous model, extremely lightweight and very small
in size. Though with this model, it obtains high resolution. This model
will replace the PANASONIC WV-KS202 around March 1994

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MOUNTING AND ITS SPECIFICATIONS:

The considerations involved in the construction of the mounting were:

strength,
weight and
durability.

The mounting had to be strong enough to hold a camera head with a lens and yet, as light in weight as possible. This is so that a patient would be able to walk with the mounting and camera on the prosthesis. Also, the mounting had to be able to withstand the variations in torque and vibrations while walking, hence, it had to be durable.

The materials considered were:

plastics,
Aluminium and
carbon fibre material.

Finally, we decided on using perspex, an acrylic material. It had the strength, was lightweight and durable.

WEIGHT:

520g

OBSERVATIONS:

We were able to bring in three cameras so as to run some tests using one of the patients as a subject.

The cameras tested were, the SONY XC-999P, Pulnix Mini Card Cam System TMC-6BE and the ELMO MP4 and the ELMO MP481. All three cameras performed very well. They all had good picture resolution so that we were able to obtain good footage. The Pulnix Mini Card Cam System TMC-6BE was a bit of a problem, in that the housing it was in was heavy for this application(although that can be taken care of, refer to page 10 of this report), and it was precarious in obtaining suitable colour for the picture.

Information was received on some PANASONIC cameras which I think are worth looking into. They are the WV-KS152, WV-KS202 and also the GP-KS252 models. So in terms of finding the right camera, the ones I have just mentioned would be most suitable for this application Both in terms of picture quality and weight.

During this project, the issue of telemetry was raised, so as to make the whole system as portable as possible and be rid of cables. So when I enquired about it there were many different ways in going about it. The simplest and coincidently the most inexpensive way of implementing it, is to use a transmitter/receiver which connects onto the camera and battery pack. We used one with the Pulnix Mini Card Cam System TMC-6BE. The transmitter/receiver we used the UT-66 video sender (UHF, Ch. 36) and it was connected in the manner just explained. The TV would pick up the picture on channel 36 and so to record some footage, all that needed to be done, was to connect a VCR to the TV.

It was mentioned on page 10, that a good picture could not be obtained by one of the TV sets. The reason for that was, because it was connected to an external antenna. Since the transmitter/receiver is not the most powerful one on the market, it needs the antenna as close to it as possible. So for optimum picture quality it is best that the antenna sits on the TV set (rabbit ears antenna would be best).

The actual circuit board of the transmitter/receiver is quite small, thus, it can be taken out of its casing and be put together with the camera as one small and lightweight package. Also, its antenna which can be easily damaged or broken off, can be replaced just as easily with a rubber ducky which is very durable.

Turning towards the mounting, as it was mentioned earlier there were a few aspects which had to be considered such as weight, strength and durability. They all play an intricate part in producing the right mounting so that the patient can walk as naturally as possible. So we came up with the following setup as illustrated.



Although our mounting was to the specifications required an incident occurred which proved how precise one has to be when planning and working through a project, and so needs to be addressed in this report.

When we were testing the Puling Mini Card Cam System TMC-6BE the bracket between the main arm of the mounting and the camera stem gave way and snapped. This is not to say, that the mounting was not strong enough, because it was the fact that the camera housing was too heavy which caused the mounting to fail. It goes to show how important strength and weight in this case and that a fine balance of the two has to be established before implementation.

CONCLUSIONS:

Looking back at the beginning of the project, our aim was to see if it is viable to monitor any pressure variations on a BK stump through different stages of GAIT, by using skin discolourations. The conclusion I have come to is that, yes, I believe that it is viable to monitor the above conditions and that using specialised cameras, video recording/editing equipment and colour enhancement/special effects generators is the way to approach it.

Through each stage of the project, the objectives changed slightly. At first, we thought that finding the right camera would be a problem. When cameras were easily found, the aspect of telemetry became of great concern. After that was overcome, the problem of making the power supply/adaptor light and portable was of prime concern.

STUMP-CAM AND BEYOND

This project can branch off to various paths. Once the hardware is established in terms of camera equipment, an important stepping stone is video imaging and recording it. Infra-red imaging could be a very possible method. Another way could be digitising the picture and working with that. Also the use of specialised pressure transducers connected to LED's or reading back to the video monitor so as to pinpoint at which stage of GAIT the patient is.

Finally, the analysis of all the footage and data obtained would be a crucial factor for the overall effectiveness of all this research and testing, since it will be the results of the analysis that will benefit the Prosthetists-Orthotists in helping their patients. So, as it can be seen, this research project can be used as a springboard which can lead into other research fields.

Therefore, not only is it viable, it is crucial that such steps be taken so that we, as Biomedical and Clinical Engineers can come up with the means for the Prosthetists-Orthotists to improve upon their efficiency. This has to be achieved so as to enhance our patients quality of life.

APPENDIX A

SONY XC-999P



APPENDIX B

ELMO MP481



MONASH UNIVERSITY REHABILITATION TECHNOLOGY UNIT
WISHES TO EXPRESS THEIR THANKS TO THE FOLLOWING.

Videocraft

IBS AUDIO VISUAL

COLLINS VIDEO COMMUNICATIONS

SCIENTIFIC INSTRUMENT MANUFACTURE & REPAIR CO.

GEC VIDEO SYSTEMS DIVISION

AND

ROBERT THORNE,

WHO VOLUNTEERED HIS TIME TO BE OUR
SUBJECT PATIENT DURING OUR CAMERA
TESTING.

STUMP-CAM

Clinical applications

Rehab Tech Clinical Placement Project.

ELISABETH LAIRD

9121255T

Dynamic Diagnostic socket/skin interface monitoring using a prostheses mounted video camera.

In recent years there has been an increase in the use of clear check sockets by prosthetists as a instrument for statically determining prosthetic socket fit. This is achieved by observing the socket/skin interface by nature of the skin discolourations under load. This has been reasonably effective by providing feedback for the clinician on how well the socket fits, however observing dynamically, the pressure distribution within the socket, which is more desirable, has not been until recently, feasible.

By mounting a video camera onto the prosthesis the frame of reference of the socket/skin interface remains static. The loading pattern changes dramatically as the patient walks. Terry Zafiriou did initial investigations on a number of different "lipstick" cameras that were mounted onto the prosthesis and assessed in terms of resolution, clarity and field of vision. The subjective opinion of the prosthetist involved was that he could clearly detect aspects dynamically that would influence his modification. These aspects could not previously be detected.

The image can be observed in real time, recorded as part of the ongoing clinical information or mixed into a special effects generator to mix the image with that of the patient walking or to colour enhance the image of the socket/skin interface.

Terry's aim was to see if it was viable to monitor any pressure variations on a trans-tibial stump through different stages of gait, by using skin discolouration.

This was achieved by using specialised cameras, video/editing equipment and colour enhancement/special effect generators. Conventional camera and video recording equipment have been used to record patients while they are walking. However the problem has

been that the camera cannot focus close into the socket, without picture distortion or being in the way of the patient while walking.

The 'lipstick' camera is mounted onto the prosthesis, looking through a transparent check socket and onto the stump.

By having the ability to observe the stump/socket interface dynamically, it is possible to monitor various pressure points during the different stages of the gait cycle. This is so to evaluate whether or not the region of pressure is excessive enough to cause discomfort to the patient. As pressure is applied to the skin, it changes colour, red is low pressure and area of white is high pressure.

So basically, by finding the appropriate specialised camera equipment which can be mounted onto the prosthesis, it is possible to monitor patient while they are walking. The camera will hopefully be able to detect various pressure changes on the skin during gait and if they are causing patient discomfort the prosthetist is able to make the necessary changes to the socket.

The general criteria for the project was that the camera and mounting must have been strong, small and lightweight as possible, so as they do not significantly interfere with the patient's gait pattern. Specific criteria for the camera included;

- small and lightweight
- able to monitor anterior, posterior and lateral views of the stump
- able to focus onto various regions of the stump

RECENT "STUMP-CAM" PROJECT

I am investigating the clinical applications or requirements of "stump-cam." Terry discovered it was viable to set a camera up, and now I'm researching as to whether it could become a clinical tool.

The first step was to contact the relevant people, that is prosthetists and ascertain whether they would consider using "stump-cam" at their facility.

This was achieved by writing a questionnaire myself, which was sent to prosthetists around Australia who volunteered their time. It included a generalised section on the prosthetic clinic's method of achieving a good socket fit and also about whether check sockets were used at all and who by.

This was followed by more specific questions on the actual "stump-cam," with emphasis on whether or not a clinical facility would find it beneficial or time and cost effective to have this equipment.

The questions, answers and summary of results is outlined at the end of this assignment.

It was determined that to follow up on Terry's initial project, it would be useful to set-up the patient, camera and video equipment again.

Ron Collins at Collins Video Communications was contacted, in regard to borrowing or renting the Elmo MP-481 camera which was selected as one of the cameras that suited the selection criteria.

A visit to Ron Collin's office at Ringwood was undertaken, where Mr. Collins discussed the possibility of other cameras that had been introduced into the market recently and may be more useful to my project. The Pulnix Macro-cam was selected.

Mr. Collins forwarded a quotation to Rehab Tech, for the supply of the equipment associated with the Pulnix Macro-cam. They were borrowed with the intent of purchasing from Ron Collins on Tuesday 6th Dec, along with necessary components, that is, cosmicar 3.7mm wide angle lens, mini UHF TV transmitter unit, rubber ducky antenna, portalac rechargeable battery and battery charger.

Greg Ingoll was employed to make cables from the battery to the transmitter to the camera control unit. This enabled the Stump-cam to be operational.

For this current project there was not enough time to remake a clear check socket for our volunteer Kerry O'Connor. A previously made transparent socket using the ICEROSS silicone liner will be used.

Minor problems

Reception

- During the trial testing (not using a stump or a prosthesis), it was discovered that once the camera was connected to the TV, the image on the screen jumped and became unclear, when the camera was blocked from the antenna. This distortion only occurred momentarily, so basically as long as the camera/antenna connection was not interfered with significantly the image was ideal.

Mounting

- With the new camera and its ability to focus within mm's of an object, the old mounting had to be revised as it was unnecessarily heavy and long. The final product was a much shorter and more practical. However in future experiments adjustments will have to be made to the present rattling and height adjustability of the mounting.

Socket

- Not enough time to make specific transparent socket.
- ICEROSS distal reinforcement, slightly difficult to see colour discolouration through it (pistoning was possible to see)

- Removed liner and changed to a cuff suspension to get clearer view. Not suspended very well, however showed pressure distribution clearer.

Things to be aware of with equipment.

- ◆ transmitter has on/off button
- ◆ battery must be unplugged when not in use, or will continue to drain charge. (approx. 8 hours to recharge)
- ◆ focus button on camera unscrews and falls off quite easily

CONCLUSION

The concept of "Stump-Cam" has raised some interest within the prosthetic clinics that I have contacted, however without further investigations and visual demonstrations it appears difficult for them to gain a clear understanding as to what the idea fully involves.

In my opinion, it appears a valuable diagnostic tool for the more challenging, hard-to-fit patients. It also allows the patient to see for themselves what is actually happening inside the socket such as pressure distribution. This, with the increased comfort, builds confidence in the prosthetist. It also helps refine the skills and improve the understanding of the prosthetist.

At the moment, further investigations will be needed to make this equipment a useful clinical tool, it may be viable to have a central evaluating facility, such as Rehab Tech, that would be available to prosthetic clinics who would like to use the equipment but are unable to either purchase or borrow it.

This project was undertaken by Elisabeth Laird, a student of Prosthetics and Orthotics at LaTrobe University, while on placement at Rehab Tech.

I would like to express my appreciation to everybody involved this project, especially to Kerry O'Connor who volunteered his time and energy, to make this investigation successful.

