Introduction

How to acquire 3D data for visualization?

◆ Computer graphics approach
  - Build everything from (almost) scratch

◆ Computer vision approach
  - Recover surface information from 2D images

◆ Others
  - Combination of CG and CV approaches
  - Use of other 3D shape recovery apparatus

Introduction

What are we aiming for?

◆ Appearance of the model
  - Realistic
  - Accurate

◆ Construction of the model
  - Harmless
  - Fast
  - Easy to apply

Shape recovery methods

Some applications of 3D models

◆ Movies
◆ Games
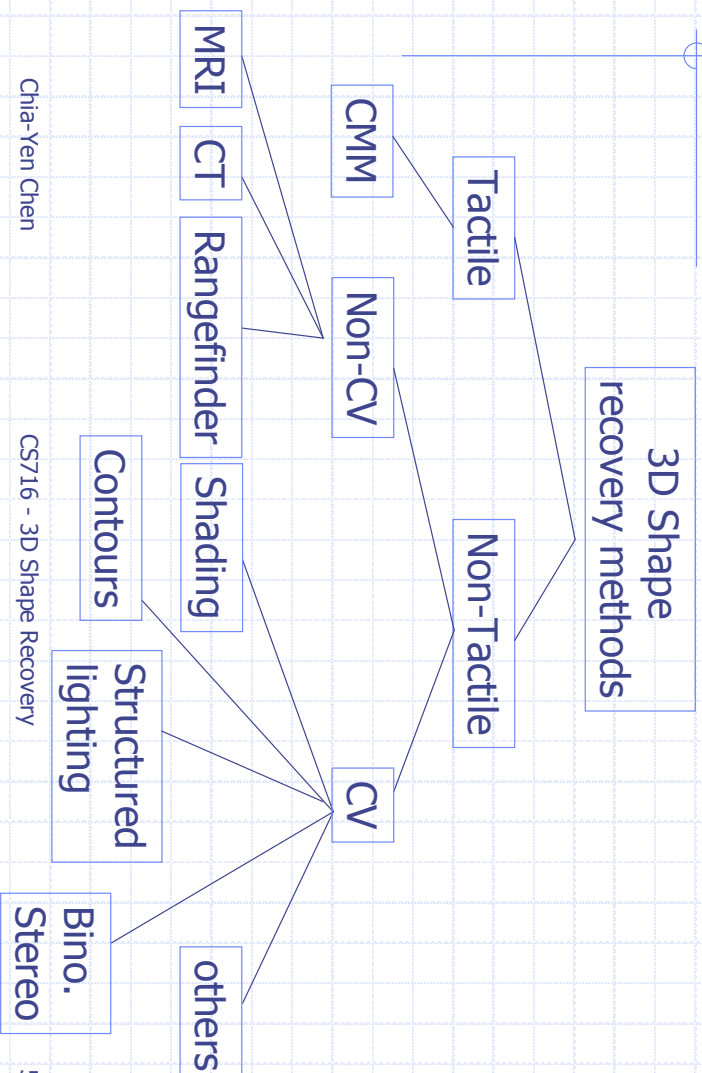◆ Medical research
◆ And many other areas

Shape recovery methods

◆ Tactile, e.g. CMM
◆ Non-tactile, e.g. CV methods
◆ Active techniques
  ▪ Projection of additional light or energy
◆ Passive techniques
  ▪ Use illumination/visible radiation in scene
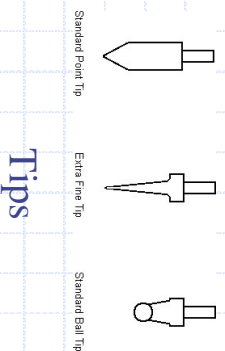
Shape recovery methods

3D Shape recovery methods

- Tactile
  - CMM
  - Non-CV
    - MRI
    - CT
    - Rangefinder
- Non-Tactile
  - CV
    - Shading
    - Contours
    - Structured lighting
    - Bino. Stereo
    - others

Coordinate Measuring Machine (CMM)

MicroScribe 3DX

Tips

Standard Point Tip

Extra Fine Tip

Standard Ball Tip

Foot-pedal

Immersion Corporation

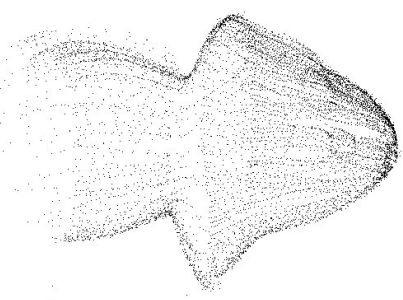Counterweight

Stylus holder

Stylus

Power indicator

Base
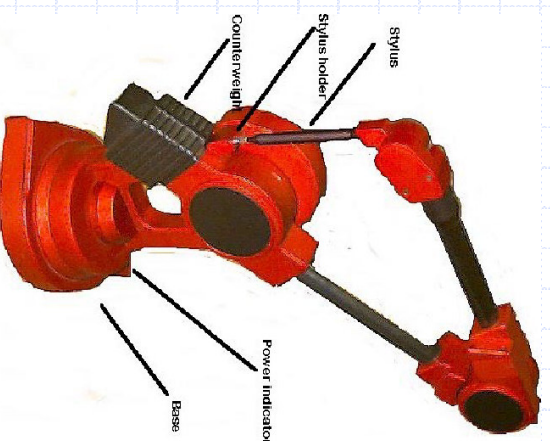
Results by CMM

- Mushroom clay model
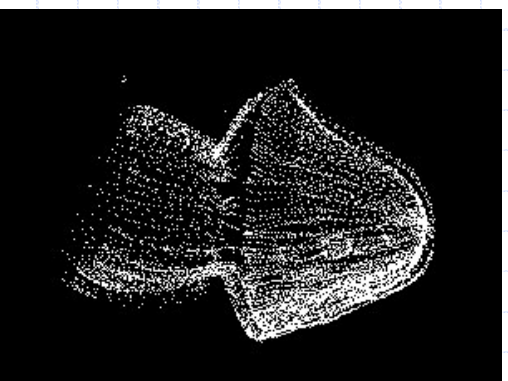- 3 hours of work
- 2,617 points
- Difficult to reach certain places on the object (under the hat and close to the bottom)
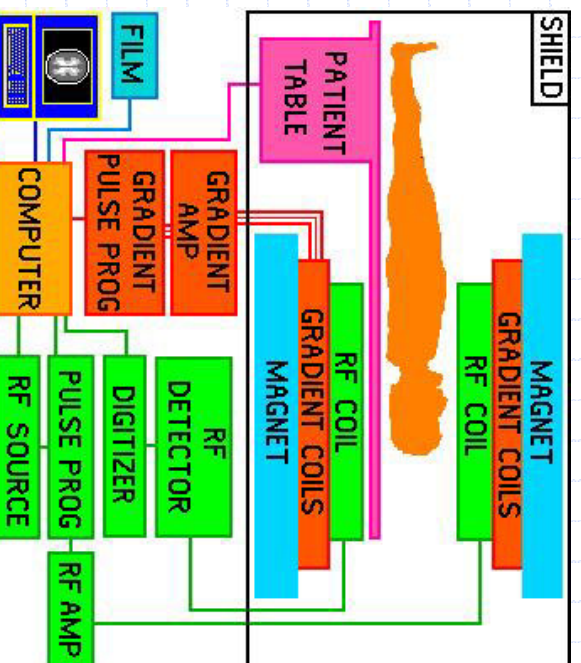- Sharp tip of stylus scratches clay

☺ Precision is machine dependent

☺ Calculations straight forward

☹ Contact with object maybe undesirable

☹ Time consuming

☹ Surface reflectance irrelevant

Magnetic Resonance Imaging (MRI)

SHIELD

PATIENT TABLE

COMPUTER
GRADIENT PULSE PROG
GRADIENT AMP
GRADIENT
FILM
RF SOURCE
PULSE PROG
DIGITIZER
RF DETECTOR
RF AMP

MAGNET
GRADIENT COILS
RF COIL
RF COIL
GRADIENT COILS
MAGNET

MRI Pictures from http://rst.gsfc.nasa.gov/Intro/Part2_26c.html
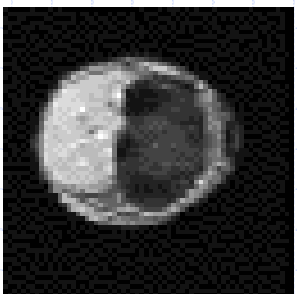
MRI for Knee

MRI for Head

Normal Dens
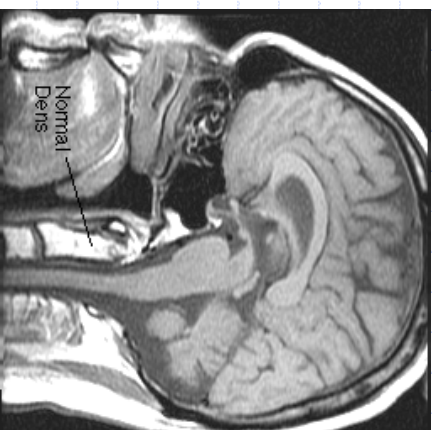
Head MRI from http://rst.gsfc.nasa.gov/Intro/Part2__26c.html
Knee MRI from http://www.debevec.org/Knee/

☺ Non-Invasive

☺ Low risk

☺ Not obstructed by bone, gas

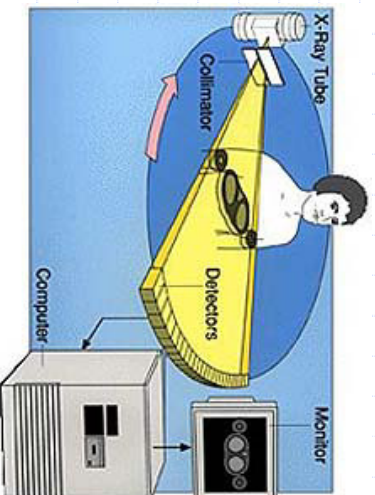☺ High quality pictures of tissues and organs

Slide 13

☹ **High Cost**

☹ **Unsuitable for patients with Pacemakers, or are claustrophobic**

☹ **Noise**

☹ **Time required**

☹ **Artifacts caused by metal objects**

☹ **Motion**

Computed Tomography

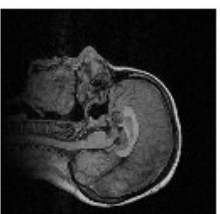CT Pictures from http://rst.gsfc.nasa.gov/Intro/Part2_26c.html

☺ Less costly than MRI

☺ Effective in identifying abnormalities in bone
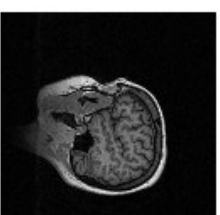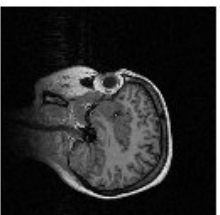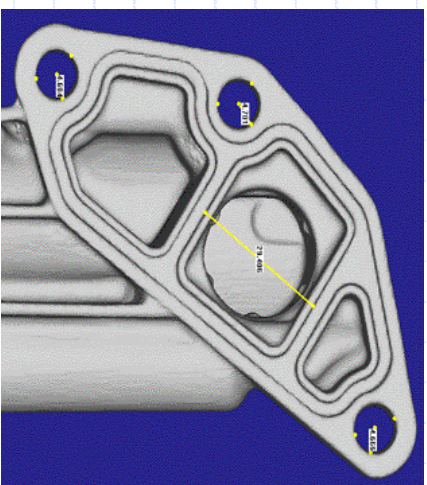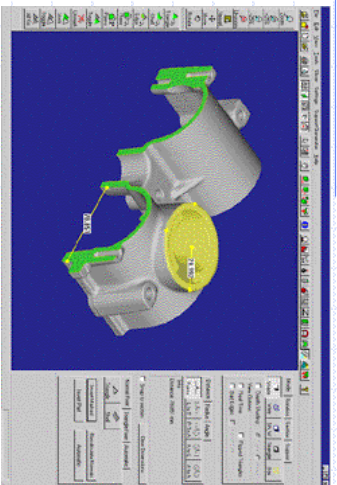
CT head pictures from http://rst.gsfc.nasa.gov/Intro/Part2_26c.html
CT parts pictures from http://www.yxlon.com/CTProject.htm

:(X-ray radiation

:(Lower quality images

:(Equipment and operation still costly

:(Use of contrast agent may cause allergic reaction

Rangefinders

laser

Rubber-armouring

TRIG-key
ON-key

Battery compartment

Receiver lens of the rangefinder

Lens protecting cap (open)

Sighting optics lens and simultaneously transmitter lens of the rangefinder

Stable aluminium housing, black anodized

Rubber-armouring

Eye for carrying strap

Sighting optics eyepiece

LR Picture from www.riegl.co.at/lasertape/images/ e_fg21_elements.gif

ultrasonic

Pictures from
http://gdam.ffem.org:1025/rangefinders.html
http://www.gazbot.com
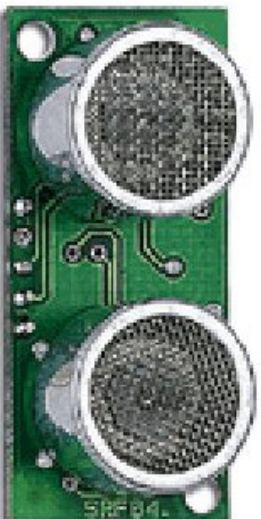
◆ Eros reconstructed from rangefinder data

NEAR — 433 Eros

Feb 12 2000 00:58:00

Eros from http://near.jhuapl.edu/Images/.Anim.html
http://www-geodyn.mit.edu/near/nlr.30day.html
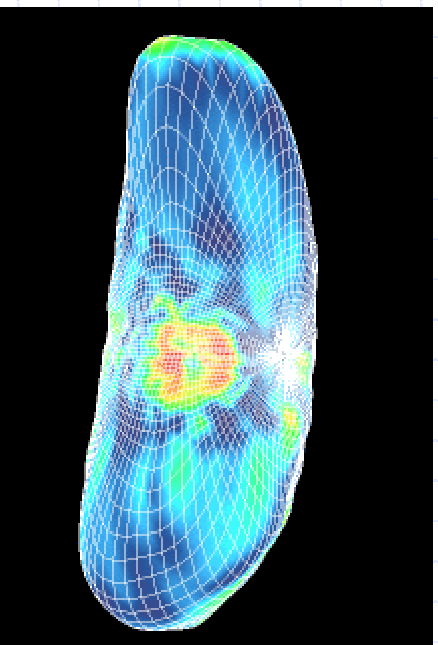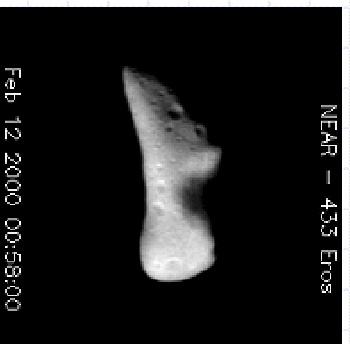
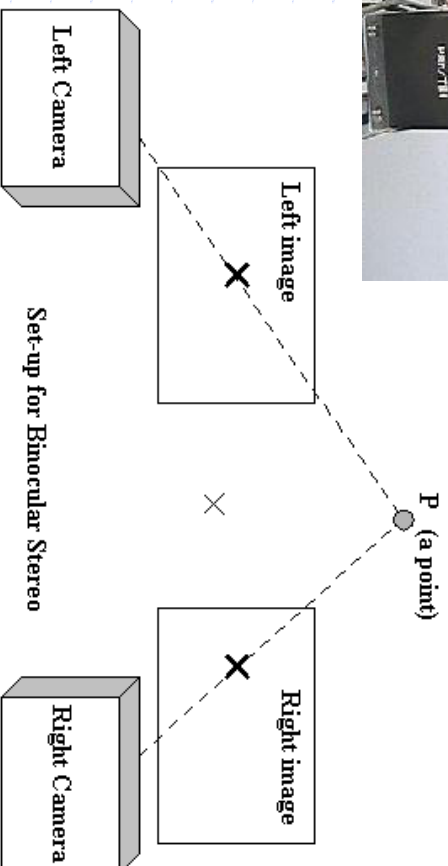☺ Relatively inexpensive

☺ Accurate (laser)

☹ Maybe unsafe

Reconstruction using computer vision methods

Shape recovery using

- ◆ Binocular/motion stereo
- ◆ Structured lighting
- ◆ Shape from contours
- ◆ Photometric stereo
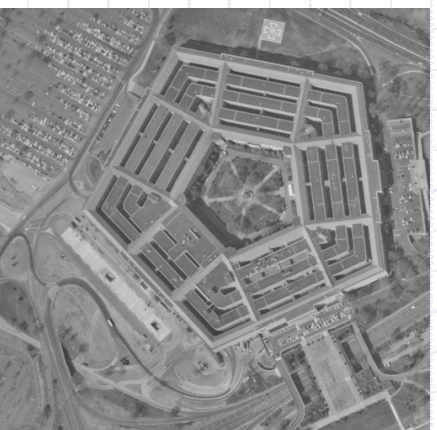- ◆ MRI/microscope images

Available NOW at CITR!

Binocular stereo

Set-up for Binocular Stereo

Left Camera

Left image

Right image

Right Camera

P (a point)

◆ Prof. Gimelfarb at CITR :

http://www.tcs.auckland.ac.nz/~georgy/research/stereo/sip-sting/Pentagon.html

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Binocular stereo

◆ Aerial photography

◆ Robotic vision

◆ Terrain reconstruction

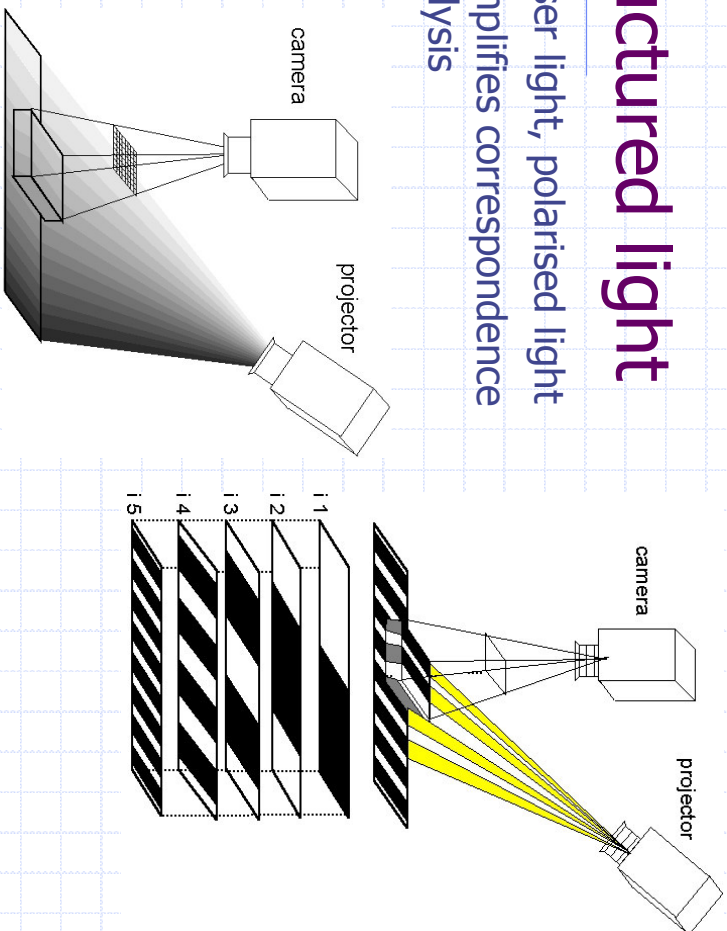◆ Depth recovery

☺ Correspondence analysis

☹ Information density

Body Measure System by TC2
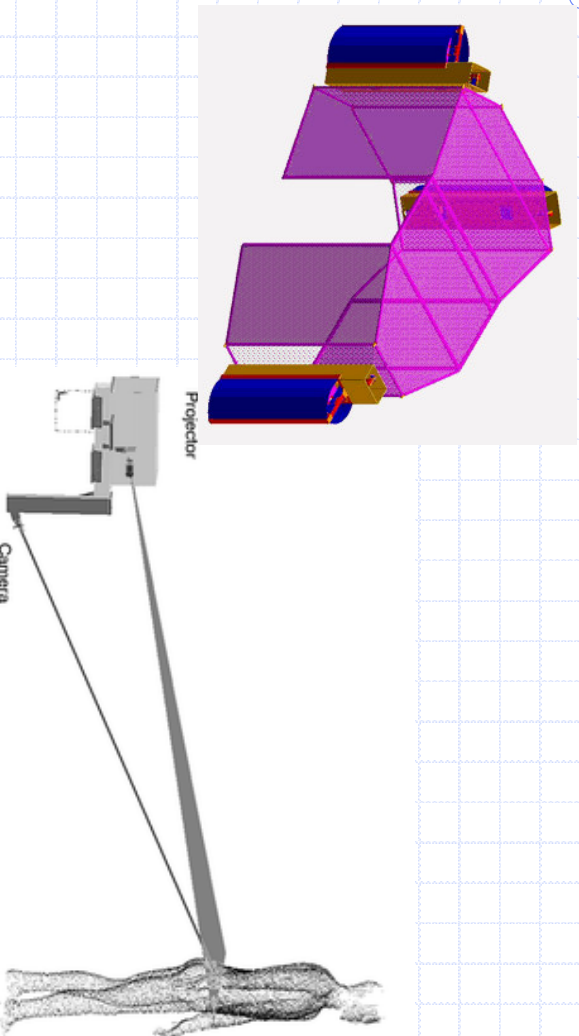
Projector

Camera

Structured light

◆ Laser light, polarised light
  ◆ Simplifies correspondence analysis

camera

projector

camera

projector

i1 i2 i3 i4 i5

2.

1.

3.
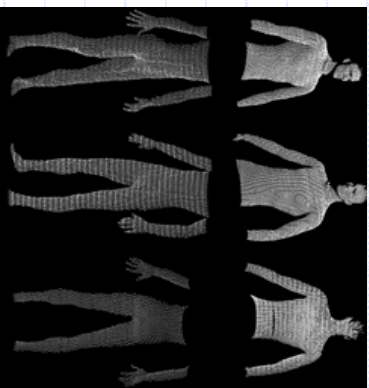
In our lab

- Stripe laser/projector for structured lighting

Camera

Light plane projector

Object on turntable

Reverse engineering

3D shape recovery

Whole body scanner, e.g. Cyberware, TC2

☺ Fast

☺ Dense information

☹ Possible use of laser

☹ Spread of light pattern
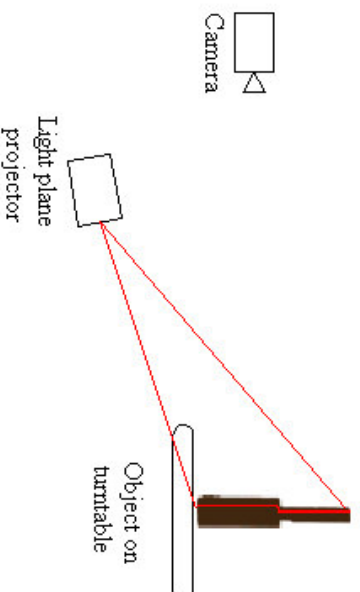
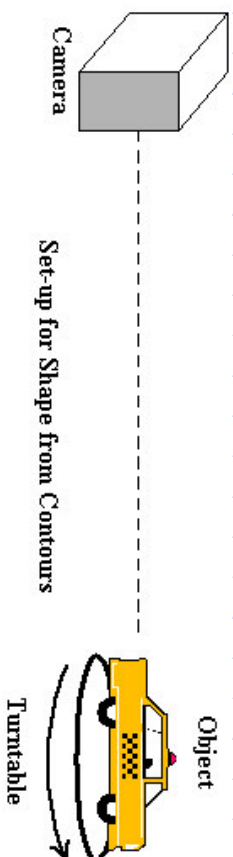Original – rock hammer

Result

Shape from contours

◆ An automatic system designed here
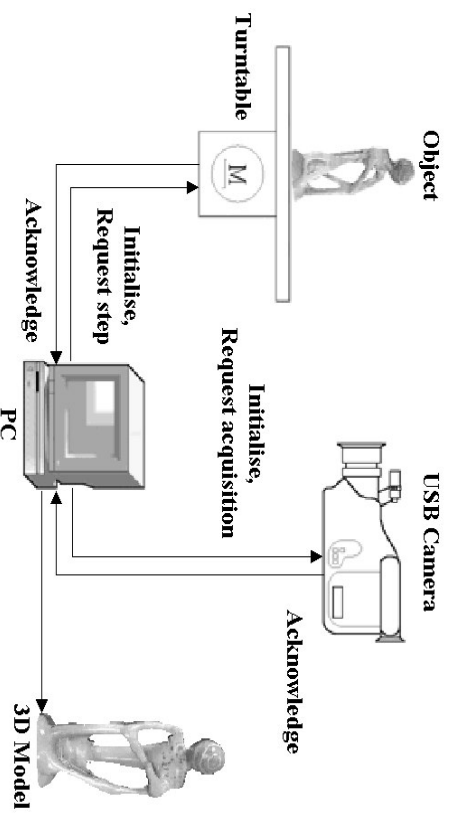
Turntable

Object

M

**Initialise,
Request step**

Acknowledge

PC

**Initialise,
Request acquisition**

USB Camera

Acknowledge

3D Model

Shape from contours

◆ Calculates 3D shape from contour information

Camera

Set-up for Shape from Contours

Object

Turntable
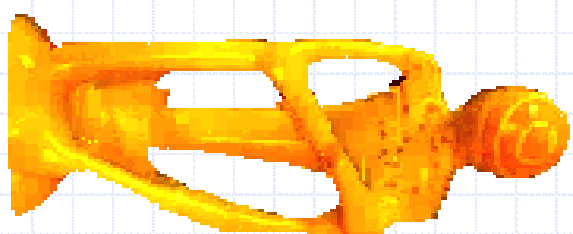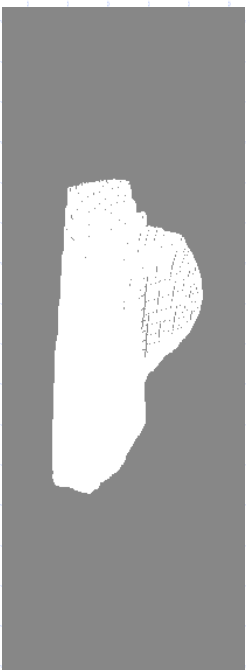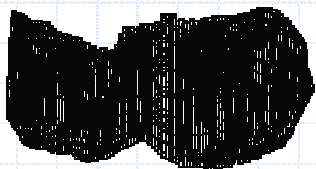
☺ Robust

☺ Handles 'holes' in object

☺ Easy set-up

☺ Effective in obtaining rough 3D model

☹ Cavity

Photometric stereo method

◆ Calculates surface depth from shading information

Light source 2

Light source 3

Object

Turntable

Light source 2
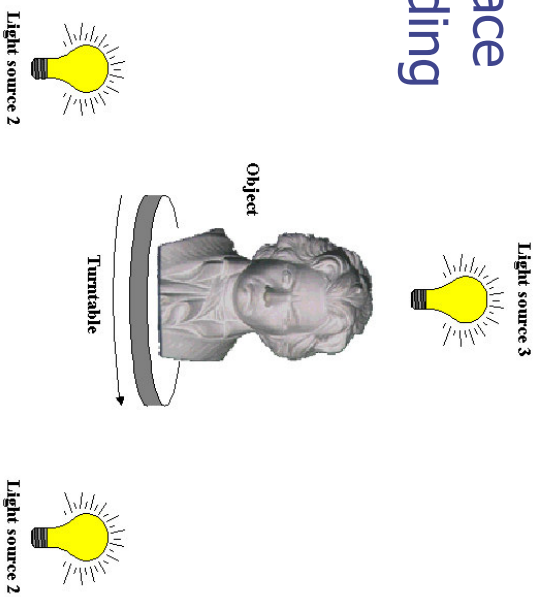
◆ Our photometric stereo system
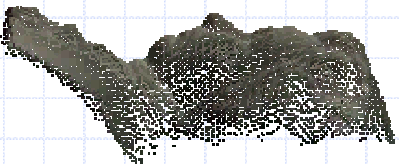
- ☺ Fast
- ☺ Dense surface information
- ☺ Very safe
- ☺ Effective for face modelling
- ☹ Lighting conditions
- ☹ Surface material

Reconstruction using computer vision methods

- 😊 Safe
- 😊 Non-tactile
- 😊 Fast
- 😊 Dense surface information
- 😊 Least disturbance to object
- 😊 Relatively inexpensive
- 😊 Easy to set-up

Reconstruction using computer vision methods

- ☹ Occlusion
- ☹ Sensitivity to surface material
- ☹ Complexity in calculation
- ☹ Ill-posed problems

Reconstruction using computer vision methods

- ◆ Reflectance
  - Shape from shading
  - Photometric stereo
- ◆ Correspondence
  - Binocular stereo
  - Structured lighting
- ◆ Contours
  - Shape from contours