# A Projection Mapping System onto a Human Body for Medical Applications

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1. Introduction

- Abdominal free flap breast reconstruction
  → require identifying and locating the blood vessels
- Related work
  → need four markers
  → position shifting problem
- The proposed method
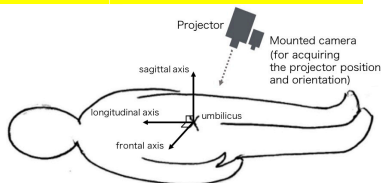 → without any markers
  → solve the position shifting problem
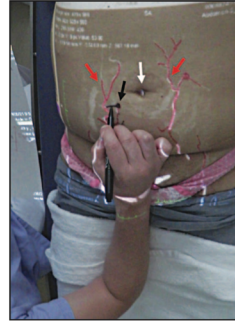
[Sostuka 2014]
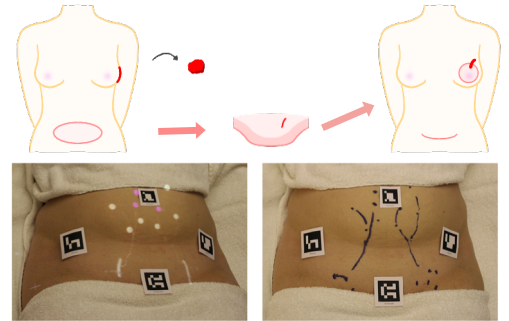
[Hummelink 2016]

2. The proposed system

- **Camera-Projector system**

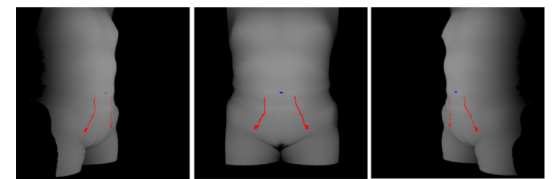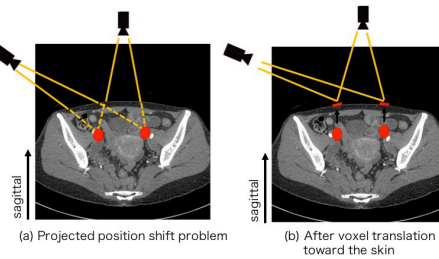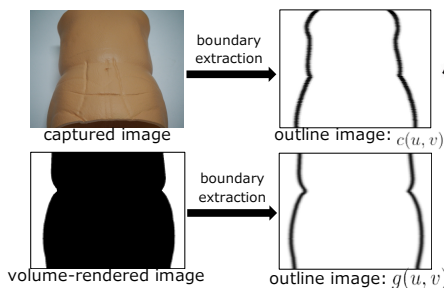- **Estimation of the camera position and orientation**
  → match the outlines of the body and a volume-rendered image
  → use the umbilicus position to reduce the number of parameters determining the camera position and orientation
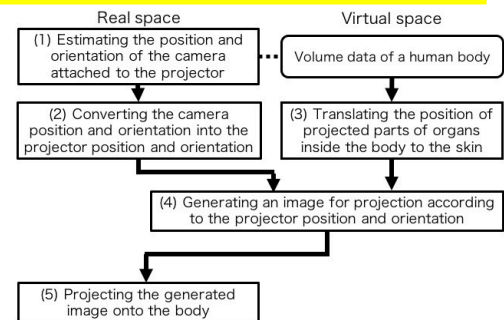 → optimization problem

$$\text{minimize} \quad \frac{1}{N_w N_h} \sum_{v=0}^{N_h-1} \sum_{u=0}^{N_w-1} (c(u,v) - g(u,v))^4$$

$c(u,v), \; g(u,v)$: intensities of outline images in a captured and a volume-rendered images

captured image → boundary extraction → outline image: $c(u,v)$

volume-rendered image → boundary extraction → outline image: $g(u,v)$

(a) Projected position shift problem

(b) After voxel translation toward the skin

- **Process flow of the proposed method**

Real space	Virtual space
(1) Estimating the position and orientation of the camera attached to the projector	Volume data of a human body
(2) Converting the camera position and orientation into the projector position and orientation	(3) Translating the position of projected parts of organs inside the body to the skin

(4) Generating an image for projection according to the projector position and orientation

(5) Projecting the generated image onto the body

- **Translation of blood vessel voxels to the skin**
  → solve the position shifting problem
  → the view of the doctor is the sagittal direction in surgery
  → the blood vessels are always projected at the predefined position where they are observed from the sagittal axis.

Projection invariant to the pose of the projector

3. Experiments

- Projection mapping onto an abdominal model from three different directions
- The blood vessels are always projected at the same position on the model
- The IoU of two regions: the skin and the projected skin
  → IoU: (a) 96.3%, (b) 95.7%, (c) 91.2%

Experimental setting
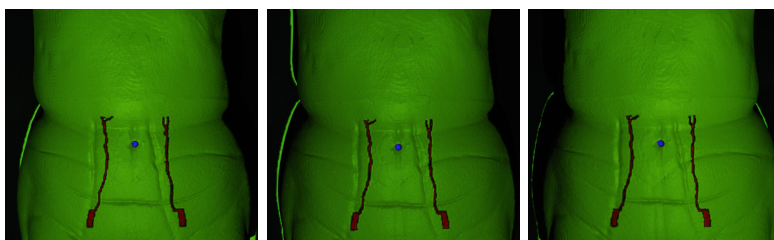
green: the projected skin
red: the blood vessels
blue: the umbilicus

(a) 8° to the left side   (b) The sagittal axis   (c) 10° to the right side

The proposed system:
an open platform camera (OLYMPUS AIR A01) and
a LED portable projector (AddTron Technology QUMI Q6)