A Point Selection Method in 3D for Computer-Aided Liver Surgery Planning

Conference Paper · June 2016

CITATIONS
0

READS
19

7 authors, including:

Xiaopeng Yang
Handong Global University
67 PUBLICATIONS **395** CITATIONS
SEE PROFILE

Nahyeon Lee
Pohang University of Science and Technology
10 PUBLICATIONS **8** CITATIONS
SEE PROFILE

A Point Selection Method in 3D for Computer-Aided Liver Surgery Planning

Xiaopeng Yang[1], Nahyeon Lee[1], Dr. Jaedo Yang[2], Dr. Ji Hyun Kim[2], Dr. Hee Chul Yu[2], Dr. Baik Hwan Cho[2], and Dr. Heecheon You[1]

[1]Department of Industrial and Management Engineering, Pohang University of Science and Technology, Korea

[2]Department of Surgery, Chonbuk National University Medical School, Korea

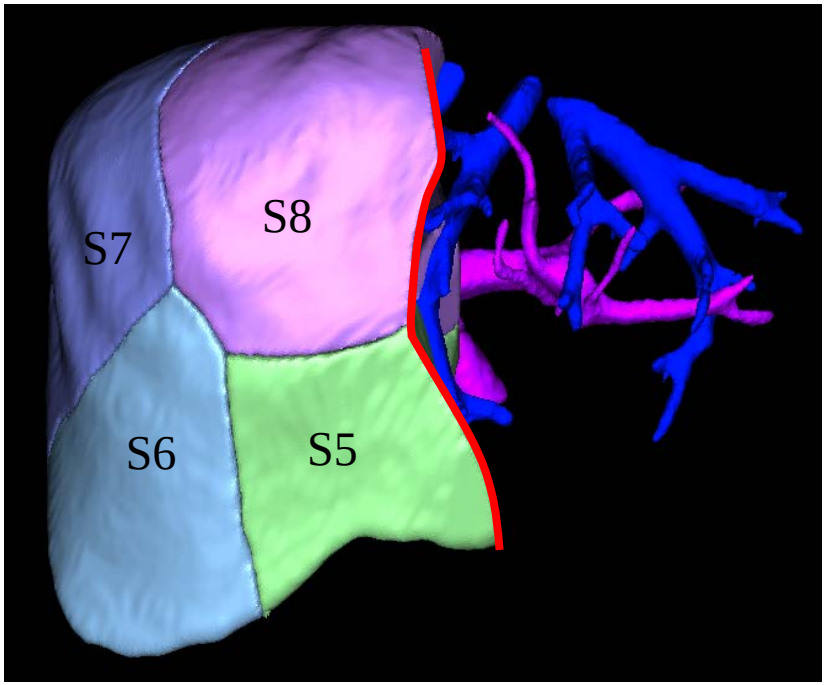
Agenda

- **Introduction**
  - **Background**
  - **Objectives**
- **Point Selection Method Development**
- **Evaluation & Results**
- **Discussion**

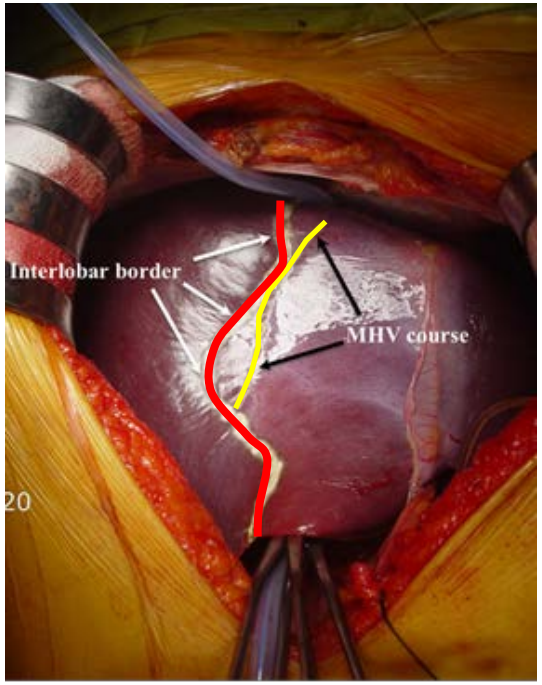
Computer-Aided Liver Surgery Planning (1/2)

- Preoperative division of the liver into segments based on vessel structure in 3D for decision of a cutting line for safe liver surgery

Virtual cutting line (red)



Surgical cutting line (red)



Computer-Aided Liver Surgery Planning (2/2)

- Procedure of computer-aided liver surgery planning

  S1. Extraction of the liver and vessels from CT images

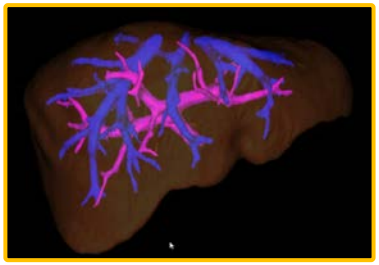
  S2. Skeletonization of liver vessel

  S3. Root point selection for identification of vessel branches for approximation of liver segments

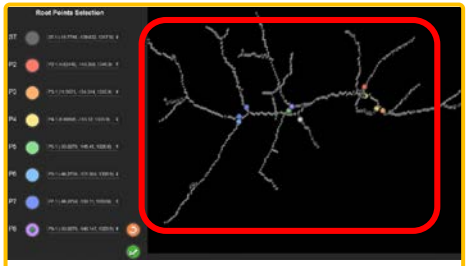
  S4. Division of the liver into segments based on the identified vessel branches

CT images

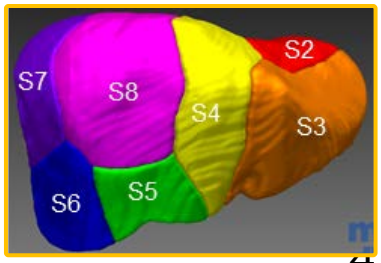
Extraction of the liver and vessels

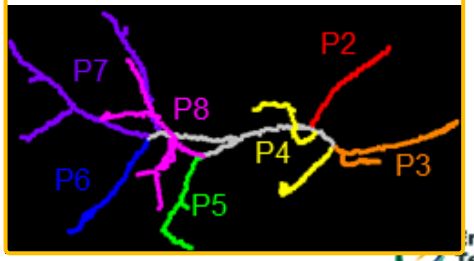


Root point selection from skeletonized vessel for vessel branch identification



Division of the liver into segments

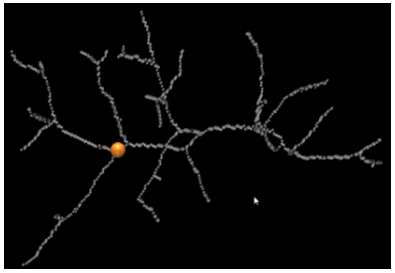




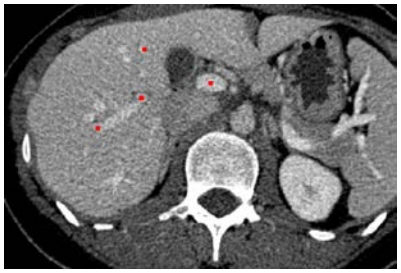
Issues of Existing Point Selection Methods

- Point selection methods
  1. Selection of a point over 2D CT slice
     - Indirect & difficult to know which point to select due to a lack of perception of 3D structure of the skeletonized vessel in the 2D CT view
  2. Selection of a point in 3D
     - Direct but difficult to correctly pick a point in 3D using the mouse

Target point to select

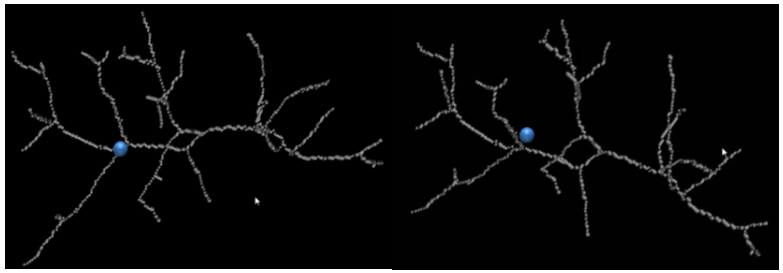


Point selection in 2D



Overlaid view of skeletonized vessel (red) with CT images

Point selection in 3D

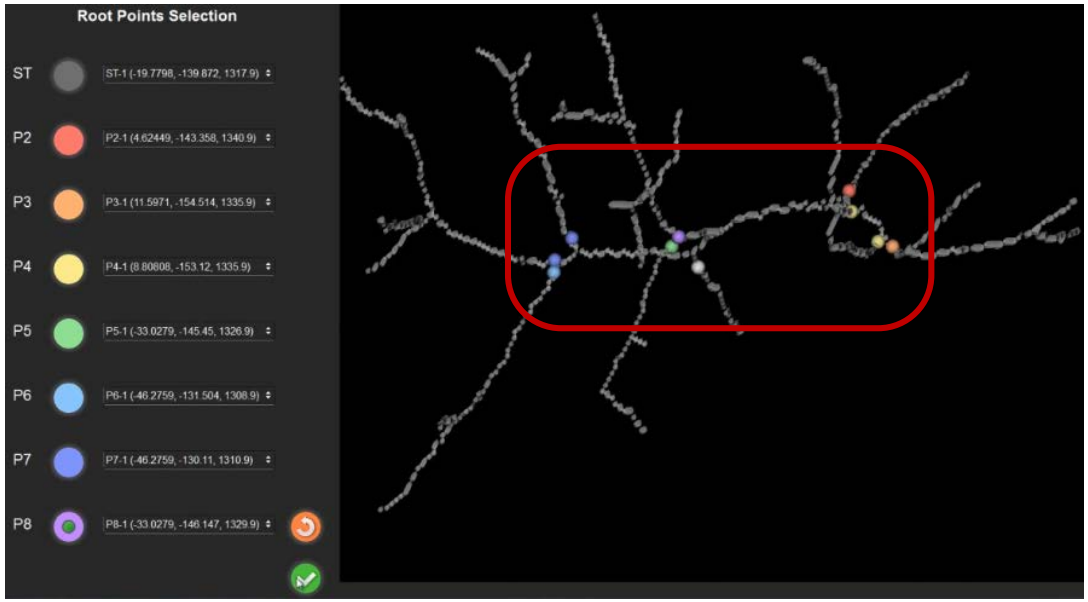


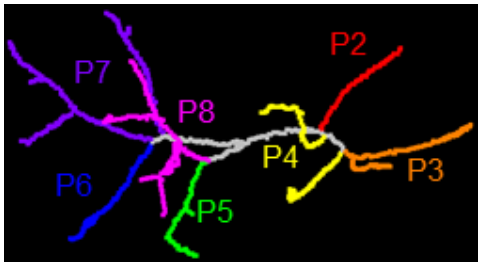
Picked point (blue) in one view

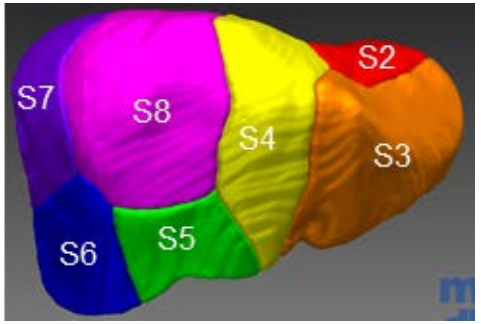
Picked point (blue) in another view

Objective of the Study

- To develop and evaluate a method for correct selection of a target point on a skeletonized vessel tree in 3D using the mouse for liver surgery planning



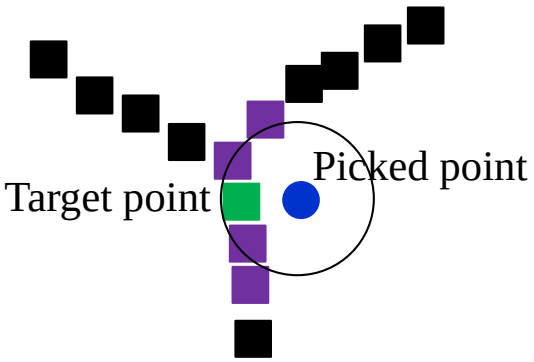




Development of the 3D Point Selection Method

- A local searching method developed for correct selection of a point on the skeletonized vessel tree
  - S1. Pick a point over the target point area
  - S2. Search neighbors of the picked point
  - S3. Identify the neighbor points located on the skeletonized vessel tree
  - S4. Find the point having the smallest distance from the picked point among the identified points, which will be the target point

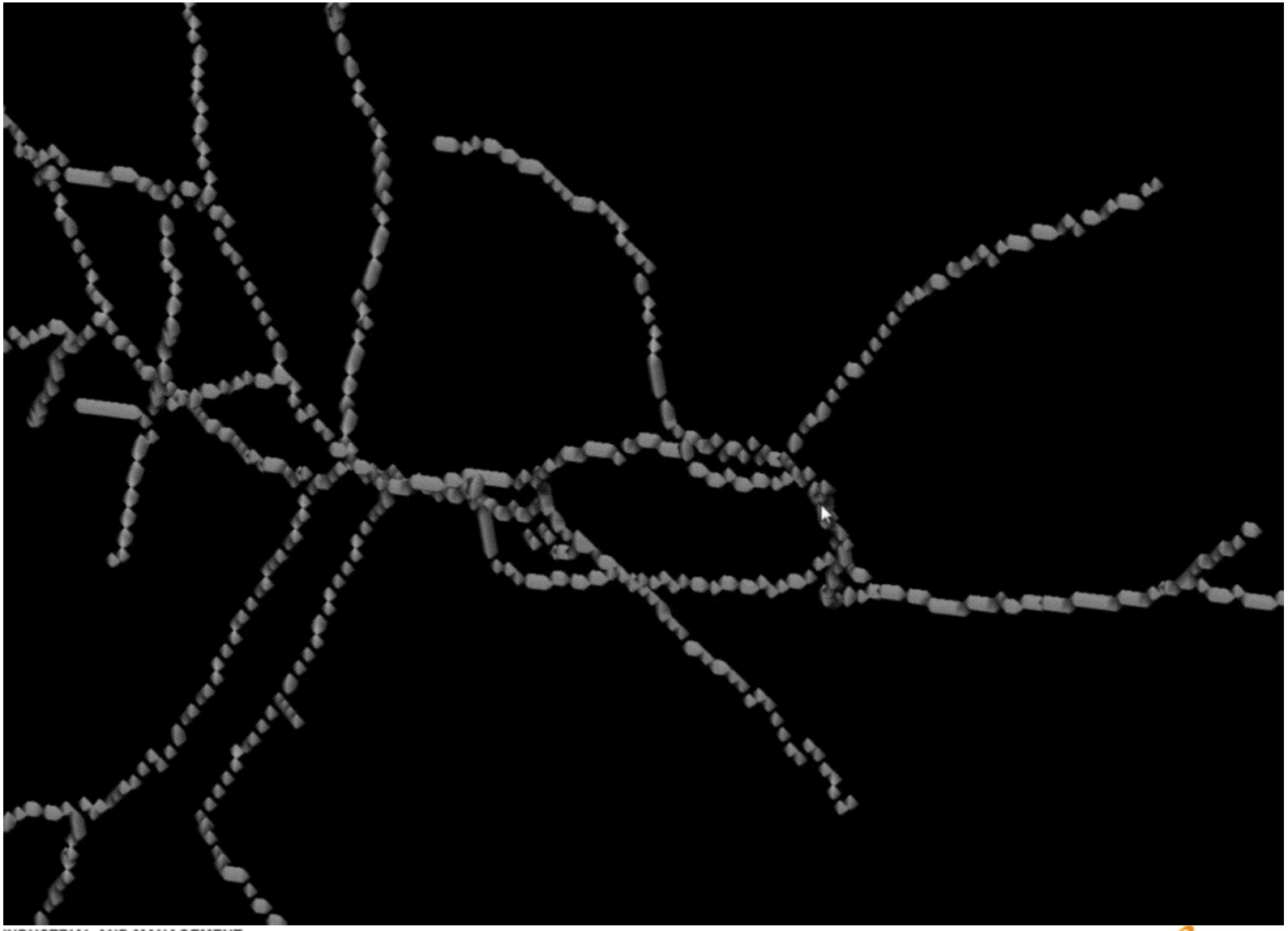
$$P_j = \text{Target point} \quad \text{if} \quad D(P_j) = \min_{i=1,\ldots,N} \{D(P_i)\}$$



Where $D(P_i)$ = Distance between P_i and the picked point

$P_i \in \boldsymbol{V}$ = Identified neighbor points on a vessel tree $\boldsymbol{V}$ around the picked point

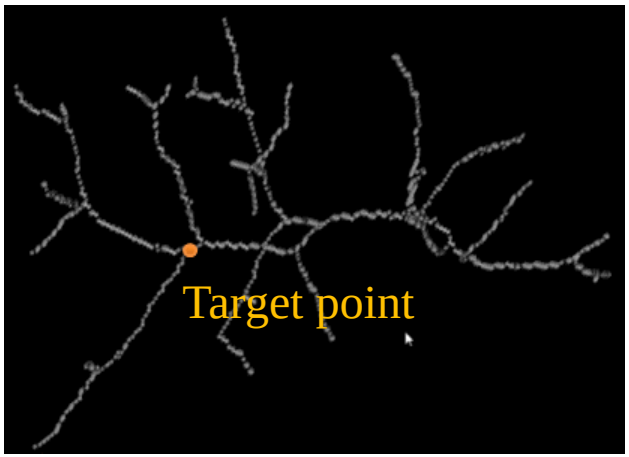
Demo of the Point Selection Method



Evaluation Methods (1/2)

- Participants
  - 3 graduate students (2 males and 1 female), aged 31.0 years

- Task
  - Pick a point in 3D by the mouse from a skeletonized vessel tree in two conditions:
    1. With the proposed local searching method
    2. Without the proposed local searching method



Evaluation Methods (2/2)

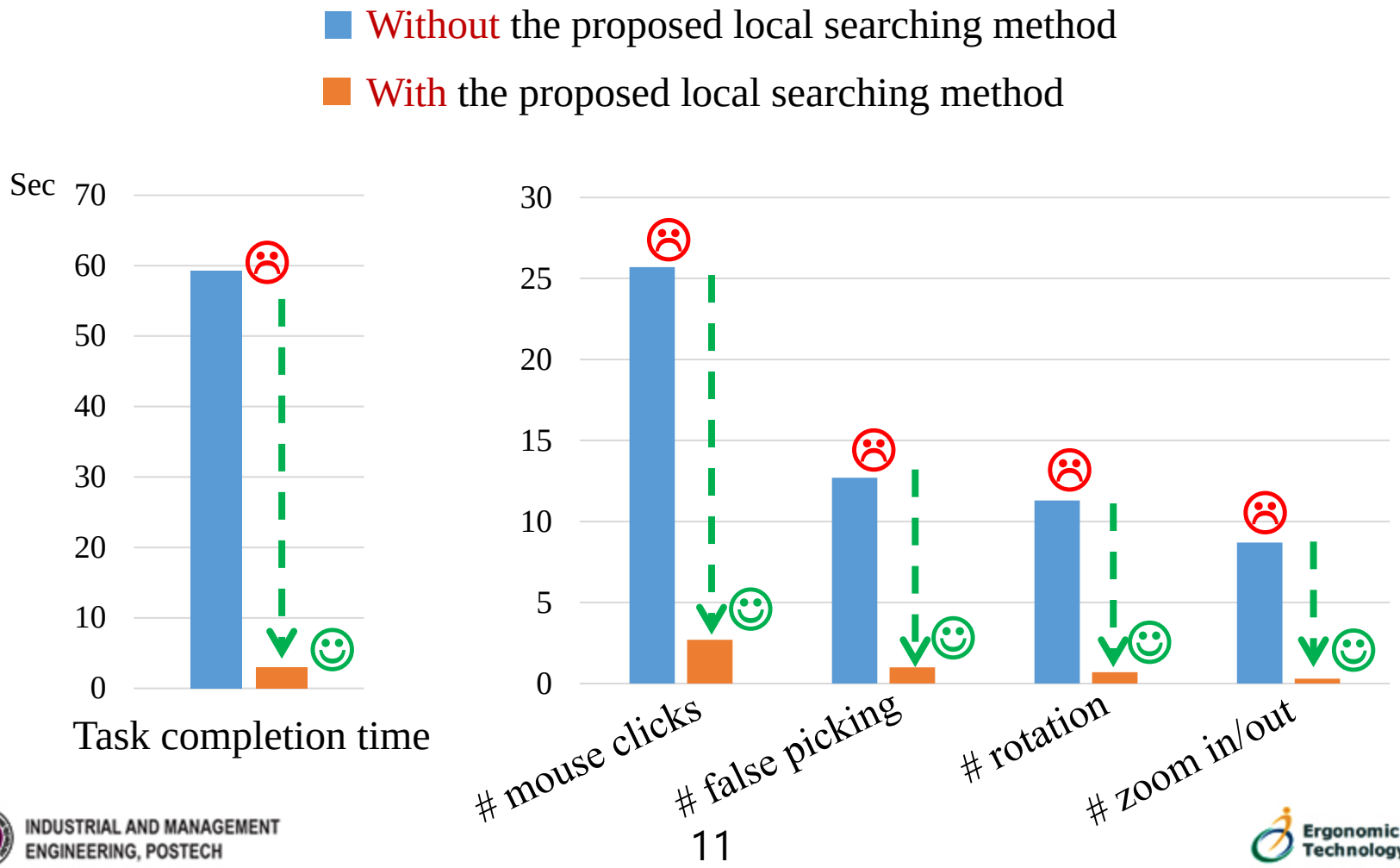
- Apparatus
  - The point selection task was performed using our developed liver surgery planning software Dr. Liver™ on a computer with an Intel i7 CPU of 3.20 GHz and a RAM of 32.0 GB.

- Measures
  - Task completion time
  - Number of mouse clicks
  - Number of operations
    1. Number of false picking before picking the right point
    2. Number of rotations of the vessel tree
    3. Number of zoom in/out

- Measurement method
  - All measures were automatically recorded by Dr. Liver.

Results

- Point picking using the proposed local searching method significantly outperformed that without using the proposed method in all the five measures.



Discussion (1/2)

- The developed local searching method dramatically facilitate a point selection task in 3D for computer-aided liver surgery planning.
- Selection of a 3D point with the local searching method outperformed that without the local searching method in terms of
  - Task completion time: 3.0±1.6 sec, 20 times faster
  - Number of mouse clicks: 2.7±1.2, reduced by 89%
  - Number of operations
    1. Number of false picking: 1.0±0.8, reduced by 92%
    2. Number of rotation: 0.7±0.5, reduced by 94%
    3. Number of zoom in/out: 0.3±0.5, reduced by 97%
- The developed local searching method can be applied to any task in which a selection of a point in 3D is involved.
  - e.g., picking up a 3D landmark from scanned body data for anthropometric product design.

Discussion (2/2)

- An extended evaluation of the proposed method with surgeons is needed.
- The local searching method can be extended with more intelligence in 3D root point selection of a vessel branch by incorporating an automatic method for identification of a bifurcation point.

Q & A

Thank you for your attention!