

HCI Design in the OR: A Gesturing Case-Study

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OR in a Nutshell:

- Collaborative Environment
- Surgical Workflow
- Distributed Platform

Computerized systems in the operating room (e.g. visualization, intra-operative navigation)

Challenges of touch-based interfaces:

- Sterility requirements
- Spatial layout of operating site

Typical solution: delegation of control to assistants

- Added level of indirection
- Misunderstandings and inefficiency



Image courtesy of Mettler Toledo



Recent Works on Intra-operative Gesture-based Interfaces

- Graetzel *et al.*, 2004: A noncontact mouse for surgeon-computer interaction.
- Wachs *et al.*, 2006: A real-time hand gesture interface for medical visualization applications.
- Soutschek *et al.*, 2008: 3D gesture-based scene navigation in medical imaging using TOF cameras.
- Kipshagen *et al.*, 2009: Touch-and marker-free interaction with medical software.
- Gallo, 2010: A glove-based interface for 3d medical image visualization.

Interaction requirements are dynamic in the OR:

- Type of the operation
- Surgeon's decision
- Patient profile

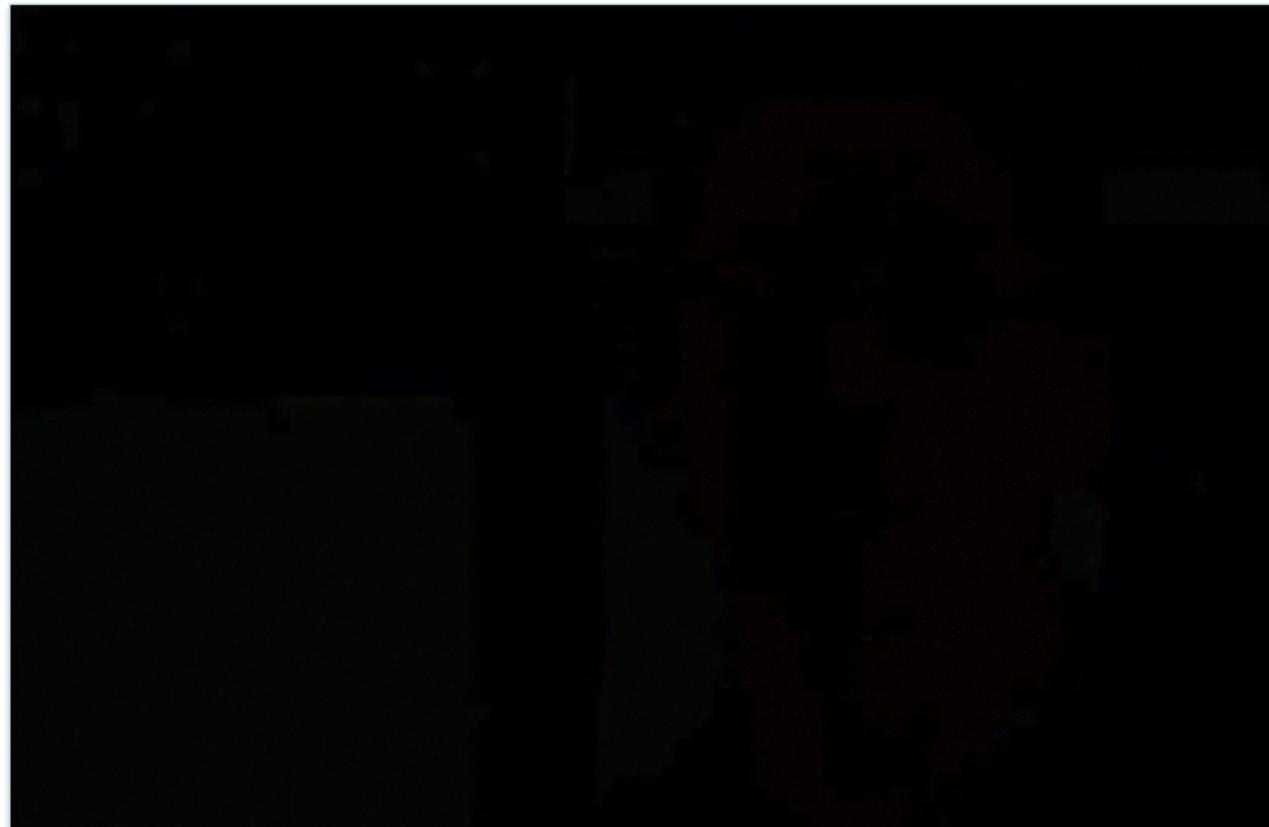
**Surgeons are limited to predefined user interfaces (UI)
The concept UI customization has been studied in
other domains but not in OR domain**

Contribution

- A HCI designing framework specific for the operating room (OR)
 - considering the main intra-operative aspects
 - surgical workflow
 - OR human roles
 - interaction requirements with hardware and software solutions
 - standalone
 - not hardcoded in the medical solution itself
- A methodology for utilizing such HCI designing concepts in practice
- Gesture-based interfaces as an example

Clinical Use Case

Surgical Stage	Available Devices
Find insertion point for catheter	Ultrasound
Insert catheter, guide wire and stent	
Confirm correct placement	Angiography IVUS
Open stent	
Validate placement and opening	Angiography CTA



Outline

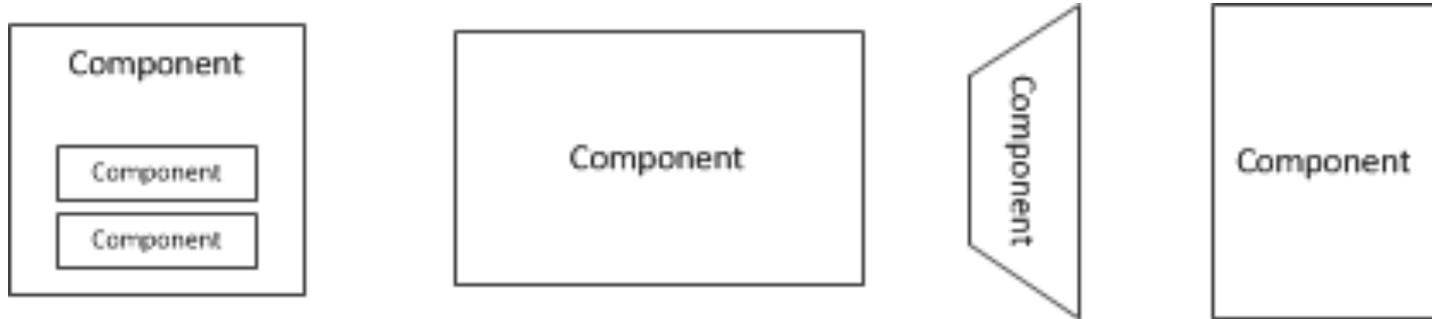
- Introduction to the OR
 - Clinical Use-Case
 - Requirement Analysis
 - Framework Architecture
 - Customization for the OR
 - Methodological Approach
 - User Studies
 - Conclusion
- HCI Designing Framework

Requirement Analysis

- **Extensibility**
 - Various input devices
 - Various target systems
 - Multiple users

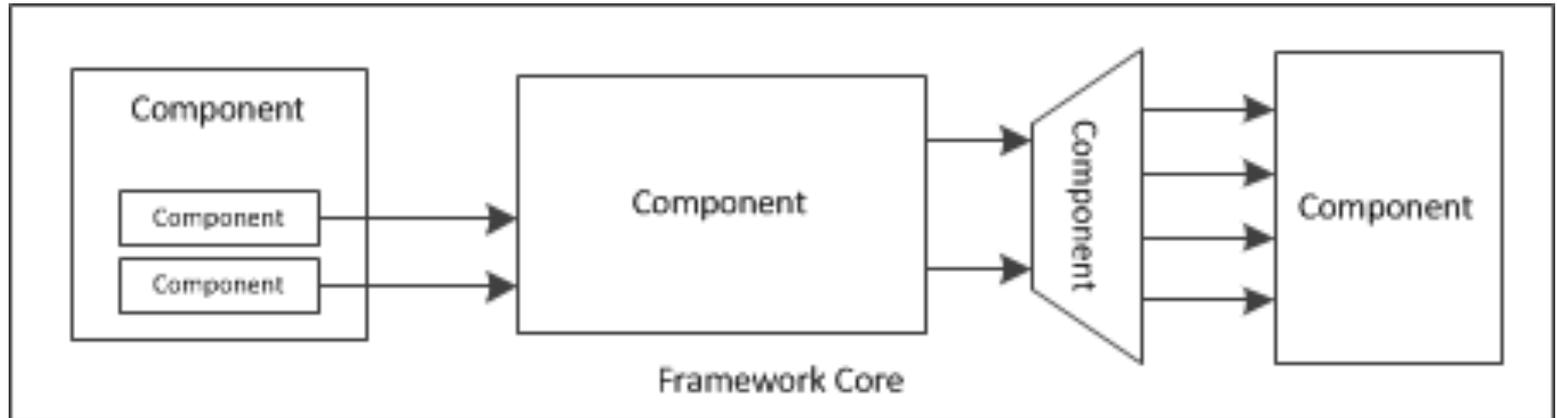
- **Customization**
 - Based on surgical workflow constraints
 - Personalized interaction
 - Gestures
 - System behavior

Framework Architecture



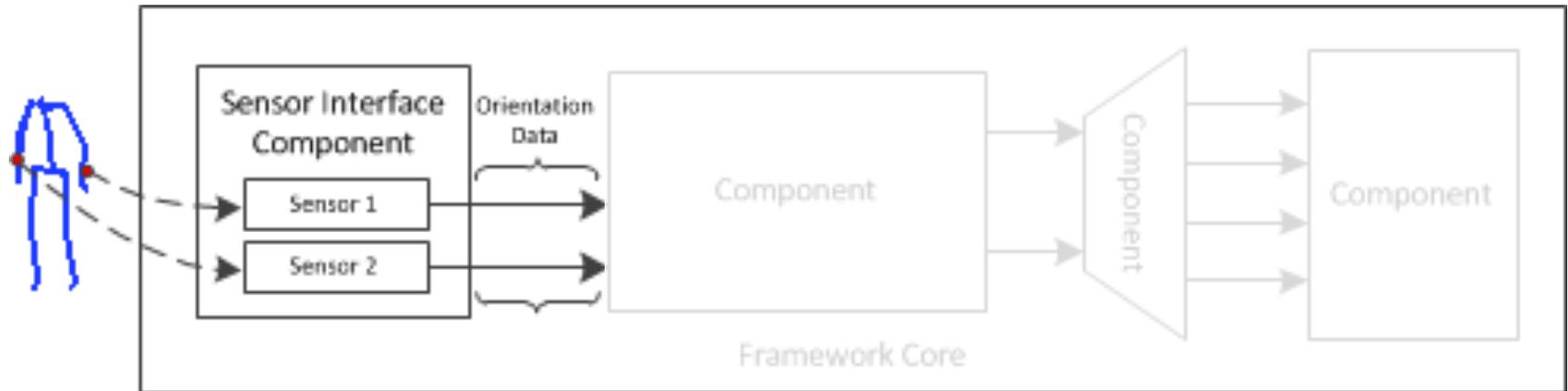
- Component-based architecture
- Functionalities are exposed as properties, methods and events

Framework Architecture



- Component-based architecture
- Functionalities are exposed as properties, methods and events
- Pipeline model for data flow between components
- Binding by linking properties of different components
- Framework core hosts, update components and propagate changes in a synchronized way

Framework Architecture



- Input Components
 - Interface to the input device hardware
- Examples
 - Kinect
 - Inertial sensors
 - Mouse / Keyboard



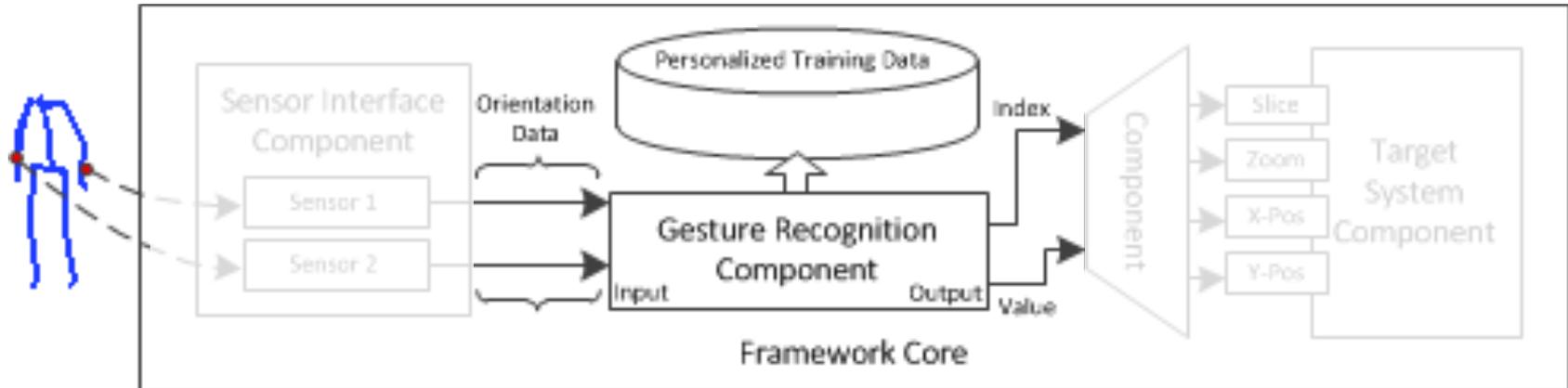
Framework Architecture



- Target Components
 - Encapsulate control interface of intra-operative target systems
- Examples
 - Intra-operative hardware equipment
 - Intra-operative software solutions

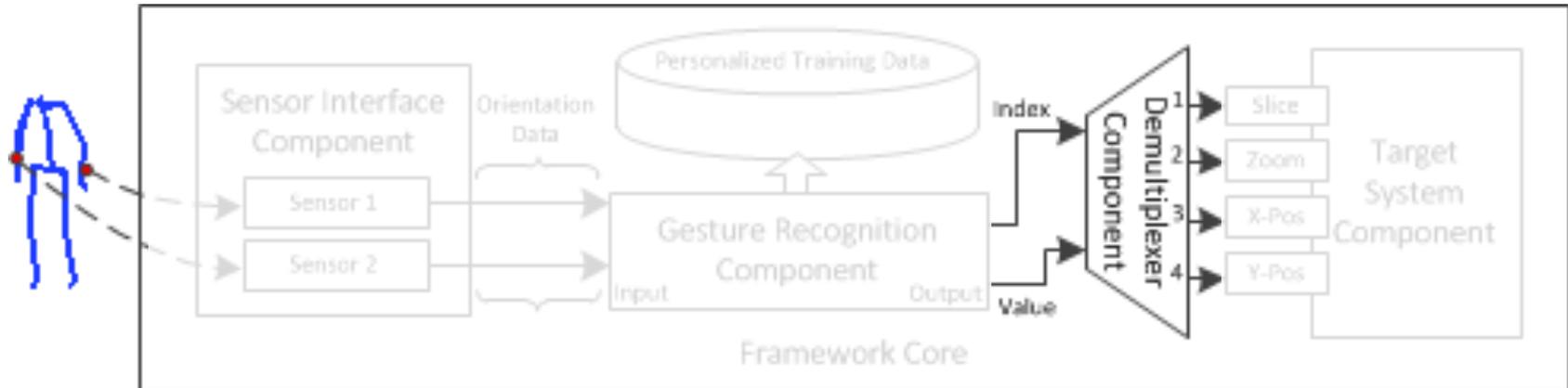


Framework Architecture



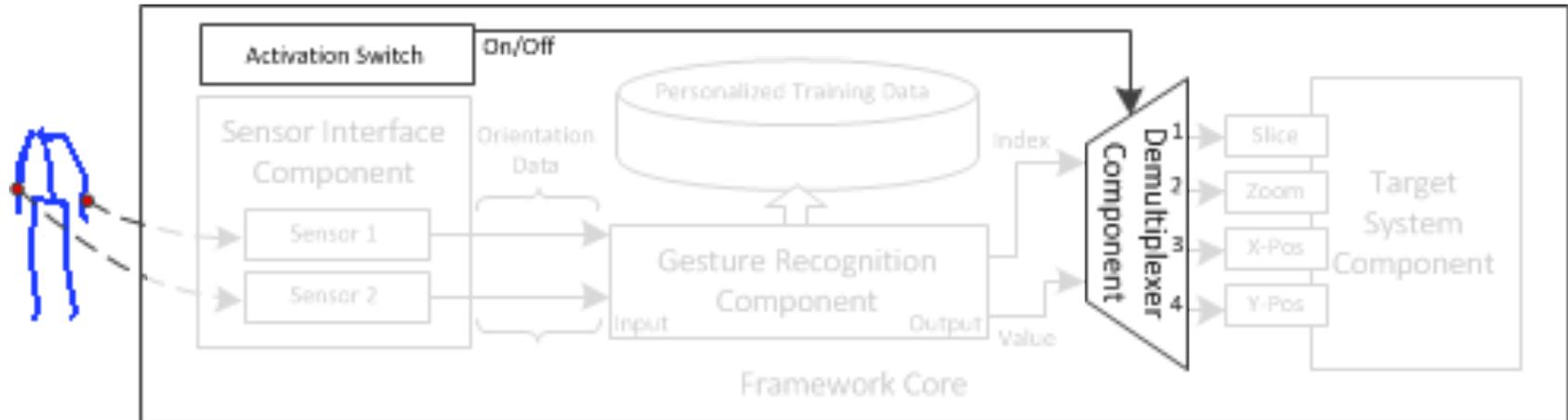
- Gesture Recognition Component
 - Implementation of the proposed gesture recognition approach
- Inputs
 - Data from input sensors
- Outputs
 - Recognized gesture index
 - Recognized gesture state

Framework Architecture



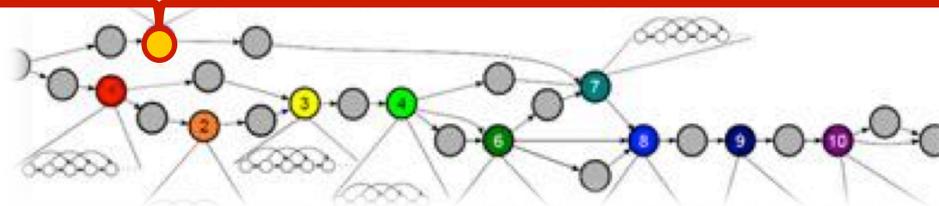
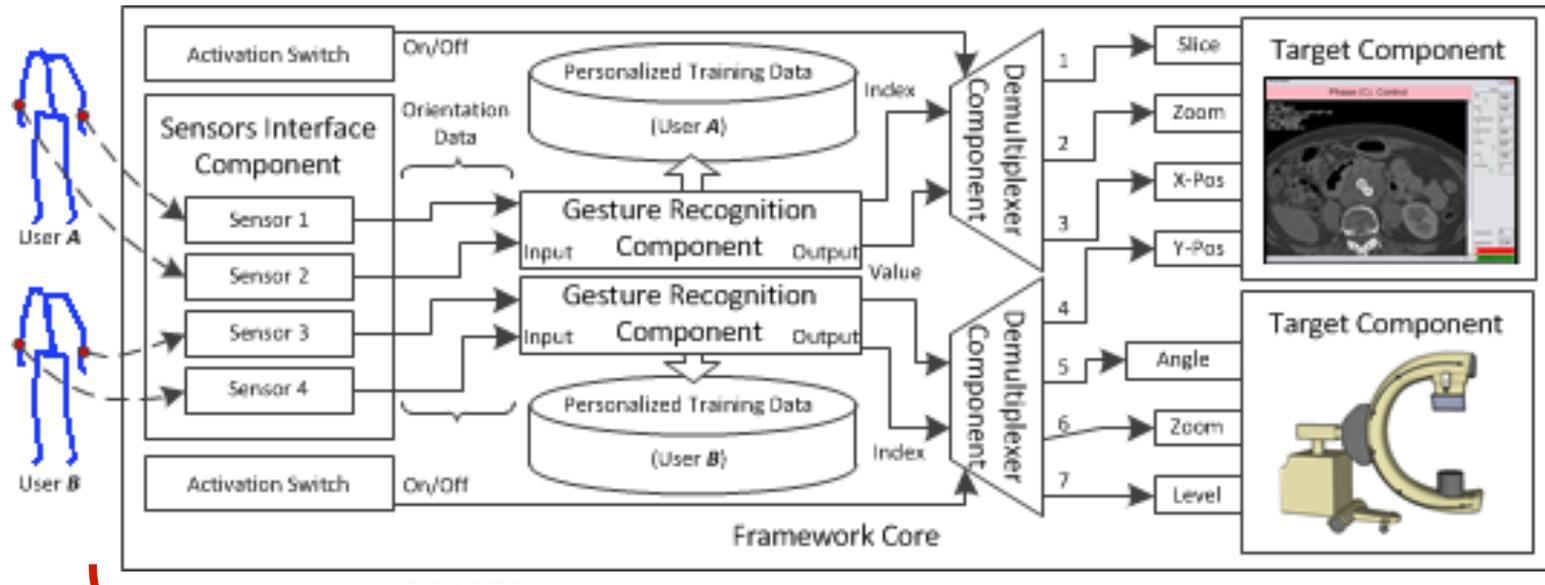
- DeMultiplexer Component
 - Forwards the recognized gesture values to one of the output channels based on the recognized gesture index
- Inputs
 - Recognized gesture index
 - Recognized gesture state
 - Activation switch
- Outputs
 - A separate channel for each of the trained gestures

Framework Architecture



- Activation Switch
 - Prevents effects of movements similar to the trained gestures
 - Implemented by enabling and disabling the DeMultiplexer component
- Possible approaches
 - Voice recognition
 - Hand-held remote control
 - Pedal

Customization for the OR



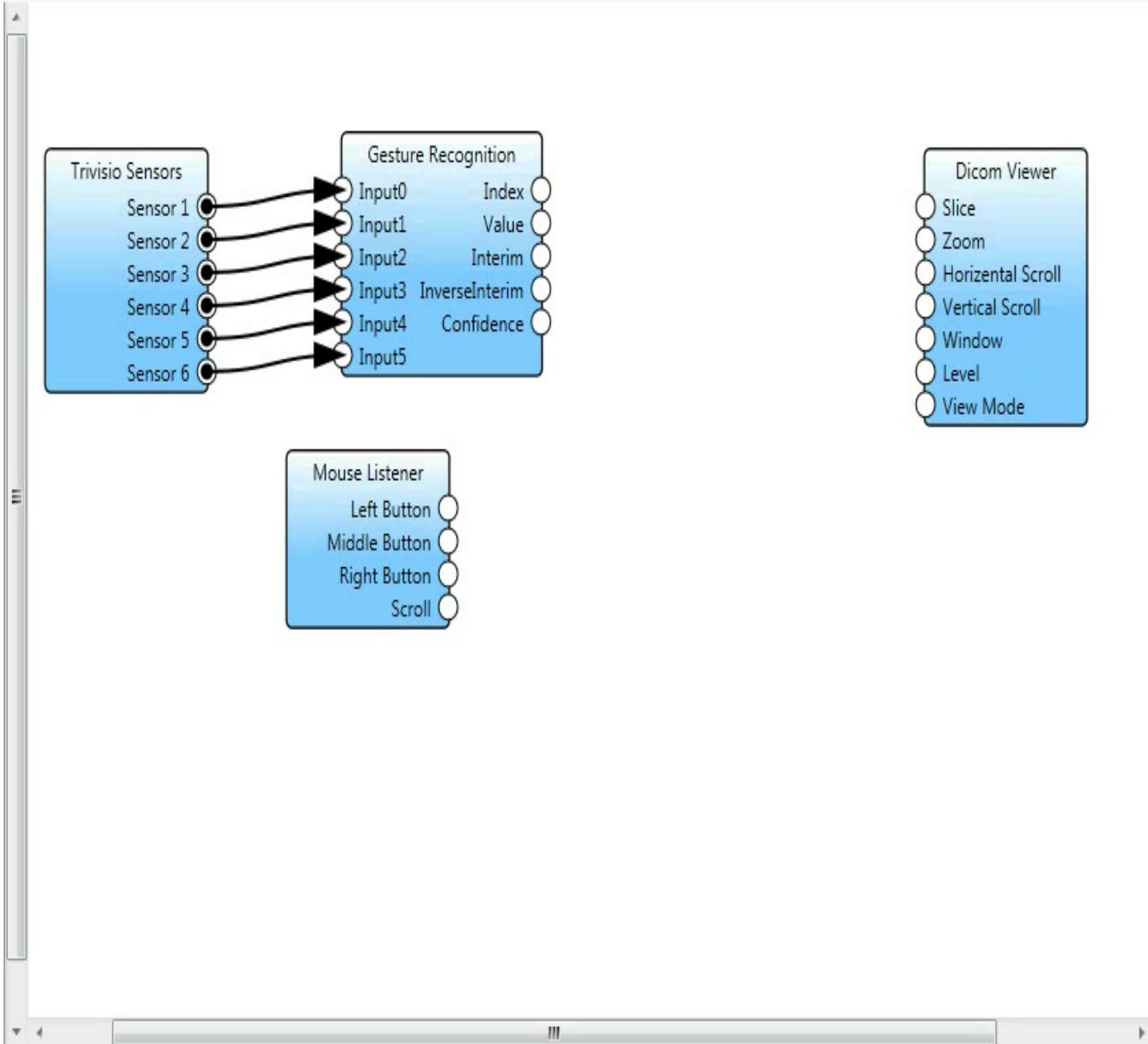
- Collaborative environments
- Extensibility and multi-target device
- Integration to surgical workflow
- Visual behavior customization by user

File Help

Input

Transition

- Double Long Converter
- String Long Converter
- String Double Converter
- String Vector Converter
- DeMultiplexer
- Gesture Recognition
- Double Range Mapper
- Double Relative Mapper
- Kinect Feature Extractor



Workflow Stages

+ - up down

[root]

Initialization

Scan

Visualization

Selected Nodes

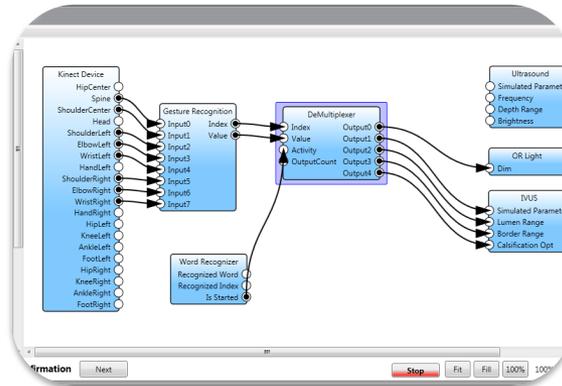
Signals Live View

Methodological Approach



Plan

- Define interaction requirements



Design

- Define interaction pipelines using the visual editor



Interact

- Load configuration and update
- Provide a subset of features to the user in recognized workflow stage

User Studies



UI Experts

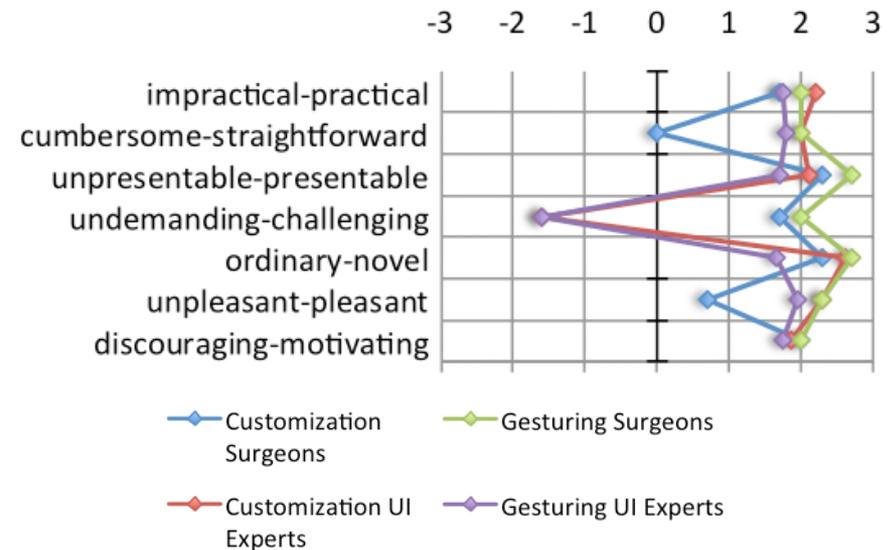


Surgeons

User Studies

- 3 tasks as in proposed methodology
 - Plan the interaction (only surgeons)
 - Design the interaction pipeline
 - Interact within the simulated OR
- Questionnaires
- AttrakDiff forms
 - Standard testing support tool for HCI
 - 28 word pairs
 - Hedonic Quality (HQ)
 - Human desires for excitement
 - Novelty and satisfaction
 - Pragmatic Quality (PQ)
 - Learnability and ease of use

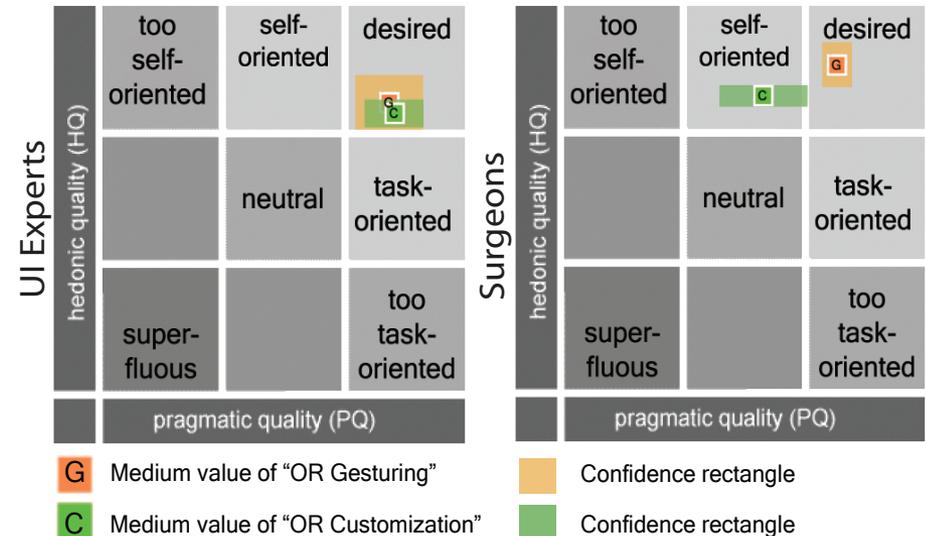
	UI Experts	Surgeons
# participants:	18	1 assistant 1 senior 1 chief
age:	mean: 35.5 σ : 8.5	31, 39 and 49 respectively
experience:	mean: 9.1 years σ : 5.3 years	3, 13 and 25 years respectively



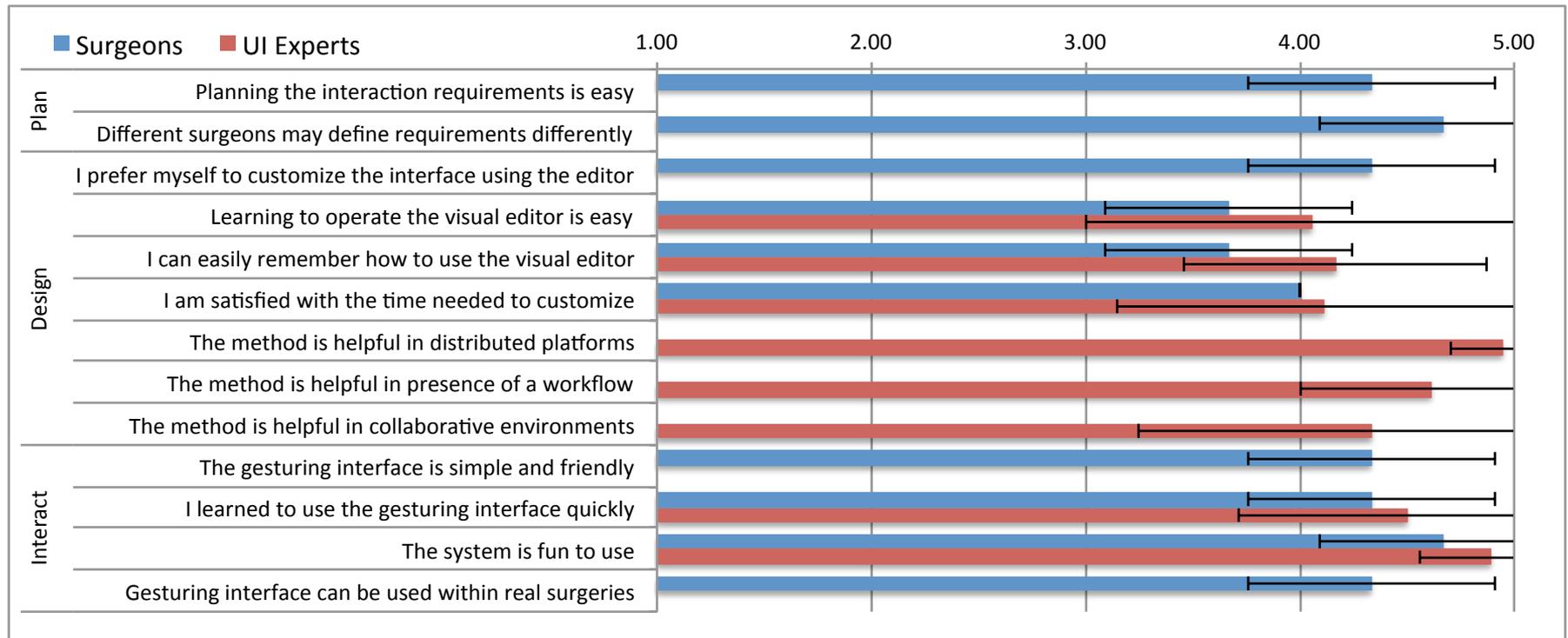
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User Studies



First experiments inside a real OR, with real surgeons, support applicability of this technique in practice.



Conclusion

- We presented HCI designing framework for the OR and a methodology
- Proposed architecture is highly adaptable based on different OR constraints
- User studies we conducted showed the applicability of the proposed concepts

Questions?

**THANK YOU FOR YOUR
ATTENTION**