# DESIGN OF MOBILE IMAGE OVERLAY SYSTEM FOR IMAGE-GUIDED INTERVENTIONS

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## Introduction

### Image-guided Needle Interventions

- Hand-eye coordination and mental registration
- Longer duration for complex procedures
- Multiple punctures and radiation exposure

### 2D Image Overlay

- Consist of mirror-monitor attached together
- Successful pre-clinical trials conducted

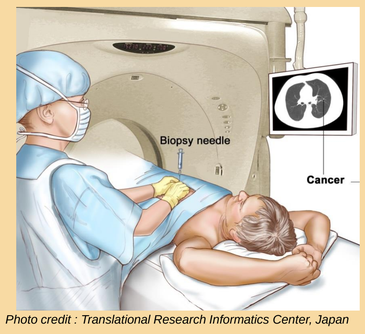
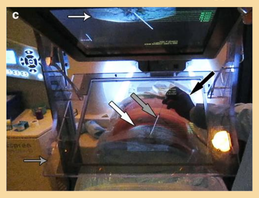



*Photo credit : Translational Research Informatics Center, Japan*

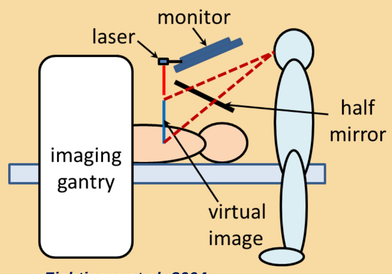
*Fritz et al; Radiology 2012;*

**Shoulder / hip arthrography**

*Fritz et al; European Radiology 2013;*



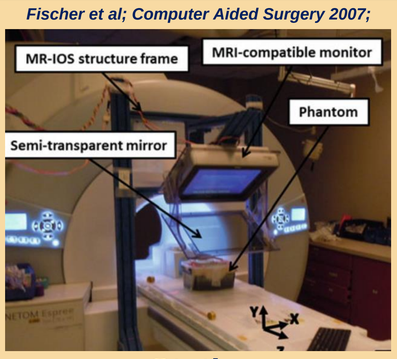
**Spine injection**




*Fichtinger et al; 2004*

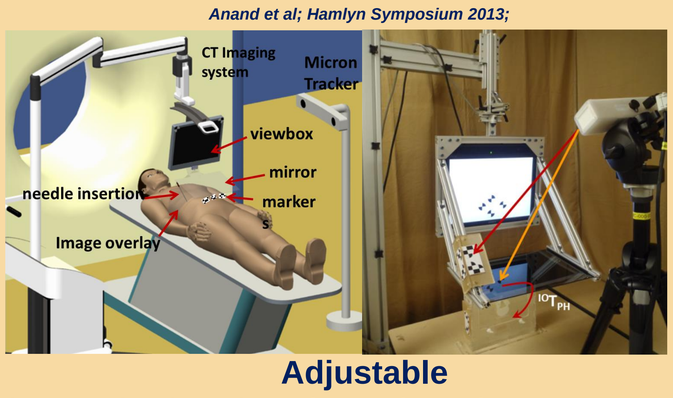
## Previous Image Overlay Systems

*Fischer et al; Computer Aided Surgery 2007;*




**Static**

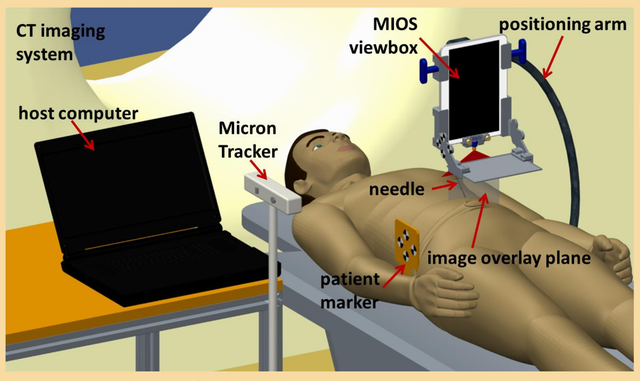
*Anand et al; Hamlyn Symposium 2013;*



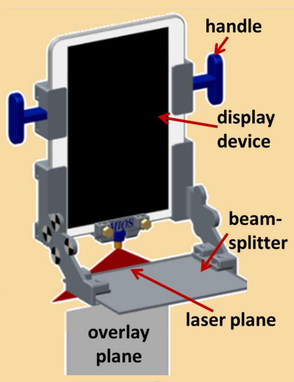

**Adjustable**

- Displayed a cross-sectional image in the virtual overlay plane
- Fixed to scanner or mounted upon large mechanical articulated arm
- Limited precision of movement and long calibration time
- Prone to misalignments, deformation, and vibrations

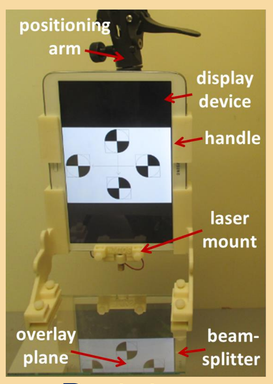
## Mobile Image Overlay System




**System concept**



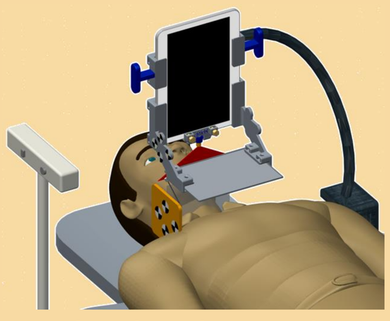

**Design**



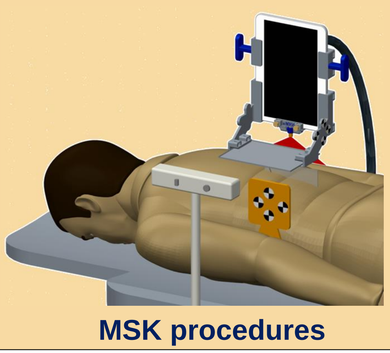

**Prototype**

- Mobile, light weight (**1.0kg**) and smaller dimensions (13 cm X 23 cm)
- Display device - **Galaxy Tab 3.0 (10.1')**
- Mirror - **Beamsplitter with Reflection/Transmission ratio - 75/25**

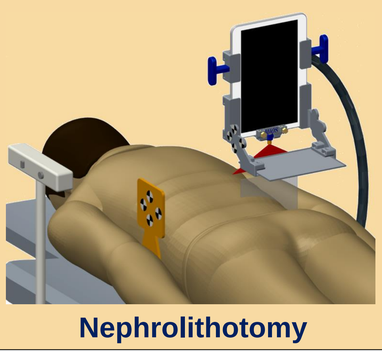
## Driving Clinical Applications



**Head and neck procedures**

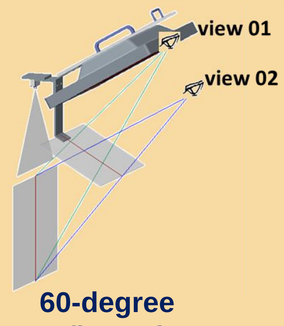


**MSK procedures**

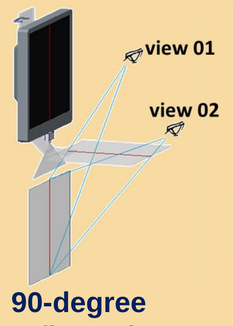


**Nephrolithotomy**

## Workspace Analysis




**60-degree configuration**




**90-degree configuration**

| | 60-degree configuration | 90-degree configuration |
|---|---|---|
| Design principle | Similar to earlier system | Newly proposed design |
| Viewing angle | 7.5 degree | 20 degree |
| Clearance above patient | 0.0cm | 5.0cm |

**90-degree configuration is optimal solution**

## Direct Automatic Calibration

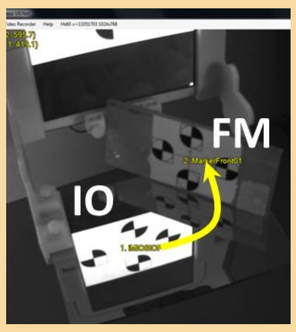
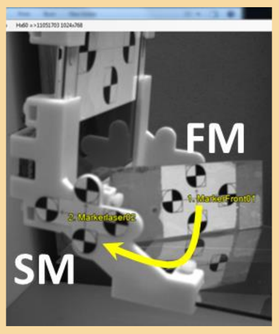
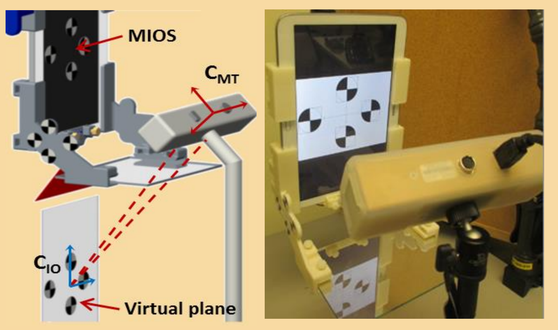



**Image overlay (IO) to front marker (FM)**




**Front marker (FM) to side marker (SM)**

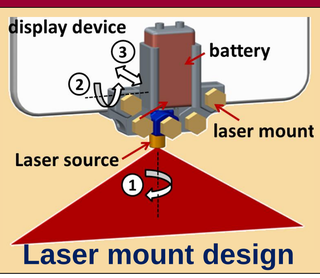



**Overlay plane pose tracking**

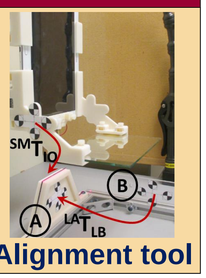
- MicronTracker can directly see markers through mirror
- Two-step, one time calibration and done away from patient
- Overlay marker tracking precision (0.1 ± 0.05 mm) similar to physical marker due to the high-luminescence display and beamsplitter.

## Laser Plane Alignment

- Laser plane marks the overlay plane
- Align two plane with alignment tool
- Adjust laser source with three DOFs
- 5mW power output (FDA Class IIIa)



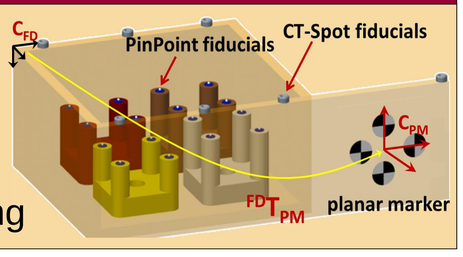

**Laser mount design**




**Alignment tool**

## Needle Insertion Validation

- Designed for needle placement experiment
- Location registered w.r.t planar marker
- Landmark registration error 1.35 ± 0.14 mm
- Actual needle placement experiment pending




## Summary and Future Work

- Light weight, smaller dimensions and automatic calibration
- System can be handheld and / or fixed with positioning arm
- Needles up to 12.5 cm length can be used
- Real-time tracking with improved accuracy of overlay plane tracking
- Evaluate needle placement accuracy and optimize clinical workflow

## Acknowledgements

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