Image Overlay for CT-Guided Hepatic Needle Insertions Cadavers Studies

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INTRODUCTION

- Liver biopsy is frequently performed to establish the diagnosis and stage in various hepatobiliary disorders
- Computer Tomography (CT) is commonly used for guiding percutaneous abdominal procedures.
- Conventional CT does not provide real-time capability. CT Fluoroscopy is useful targeting technique, however significant radiation exposure to physician and patient occur.
- Presently, no technical solution exists to assist free-hand CT guided needle placement in accurate simple and feasible manner without imparting additional radiation.

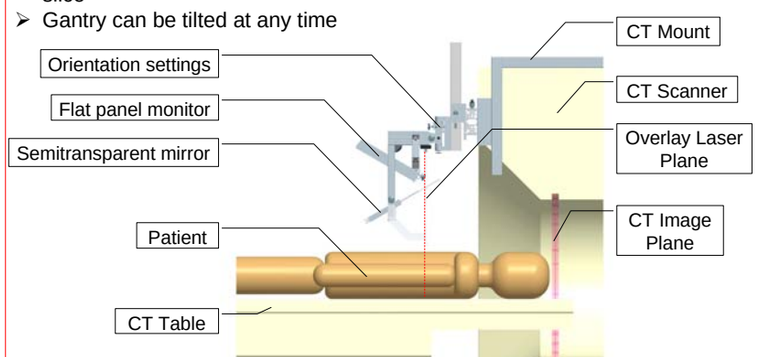
OBJECTIVE

- The goal of this study is presenting a two-dimensional image overlay device to assist hepatic needle placement on CT scanners.

APPROACH

Augmented Reality on CT Scanner:

- CT image is acquired and displayed on the flat panel display
- Through a semi-transparent mirror, clinician sees the reflection of the CT image in place over the patient
- Laser plane parallel to the image plane guides the clinician to stay in-plane
- Visual guides are displayed to indicate the angle and depth
- Fiducial markers (IZI biopsy strips) are used to confirm the entry point and slice
- Gantry can be tilted at any time



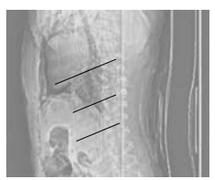
METHODS

Procedure Workflow:

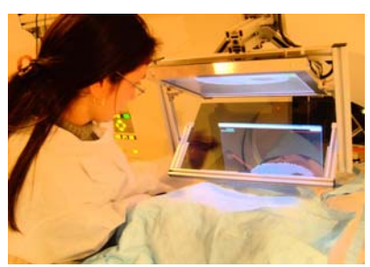
1. Scan Volume of Interest
2. Select insertion slice
3. Place IZI Biopsy Markers using the CT image plane laser
4. Scan the slice of insertion with markers in place
5. Move CT table to align insertion plane with CT Overlay laser
6. Select target and entry point on Overlay Console
7. Place needle tip on IZI markers then align needle to laser plane and overlaid guides
8. Insert needle
9. Take a confirmation CT slice
10. If the needle placement is correct, proceed, otherwise return to (7).
11. Insertion and biopsy

Optional:

- Acquire a lateral scout image of the patient
- Measure orientation of ribs and tilt gantry to have clear paths to the targets



EXPERIMENTS



Animal Cadaver Study:

- Fresh dead pigs are kept on ventilator and under warming blanket
- Fiducials are inserted as target points (staples or small metal balls)
- Ventilator is paused to simulate breath hold during imaging and insertion
- Goal is to touch a target with the tip of a 18G needle (3 different pigs, up to 6 different targets per pig and for each target up to 3 entry points)
- Take a confirmation volume around insertion plane for analysis

PRELIMINARY RESULTS

Experimental Data

Trial Number	Targeting Error (mm)	Target Motion (mm)	Insertion Depth (mm)	Depth Error (mm)	Insertion Angle (degrees)	Angular Error (degrees)
1	6.45	0.50	53.55	0.28	41.7	2.1
2	2.11	2.63	56.54	-2.26	32.3	1.1
3	6.13	4.47	59.55	0.57	-2.3	-2.6
4	4.06	1.50	22.66	0.56	94.0	9.1
5	2.77	0.90	31.05	-0.68	40.8	1.1
6	6.71	0.71	28.10	0.18	0.0	-4.3
7	4.50	1.50	36.40	3.26	63.9	4.9
8	5.29	1.21	37.83	1.14	83.6	-0.4
9	2.77	2.28	28.94	2.06	55.0	5.2
10	2.71	2.28	40.55	0.57	28.9	0.8
11	3.31	2.02	55.60	-1.69	40.6	-0.1
12	3.79	0.42	54.68	-0.06	78.1	-0.2
13	3.71	2.73	75.07	1.25	23.4	-0.5
14	1.12	1.57	83.18	1.12	63.1	1.1
15	5.00	4.46	54.63	5.84	50.6	-1.5
16	2.97	1.61	54.84	0.79	64.7	-1.0
17	1.86	14.30	97.82	2.17	99.4	2.3
18	2.09	3.74	65.81	2.92	83.6	-0.7
19	7.51	4.73	63.19	4.67	57.0	-3.9
20	5.11	5.28	64.04	3.96	39.8	-2.9
21	0.89	1.55	46.51	2.59	116.6	0.1
22	3.44	4.84	47.78	2.94	85.1	-0.4

Summary Statistics

	Targeting Error (mm)	Depth Error (mm)	Angular Error (degrees)
Average	6.4	0.3	2.1
Median	2.1	1.1	1.1
Std. Dev.	1.8	2.0	3.1
Maximum	7.5	5.8	9.1
Minimum	0.9	0.7	1.1

Correlation Matrix

	Trial Number	Targeting Error	Target Motion	Angular Error	Depth Error	Insertion Depth	Insertion Angle
Trial Number	1.0000	-0.2699	0.4218	-0.3719	0.6408	0.4454	0.4955
Targetting Error	-0.2699	1.0000	-0.1114	-0.3602	0.2141	-0.2285	-0.4669
Target Motion	0.4218	-0.1114	1.0000	-0.0870	0.3762	0.6420	0.2095
Angular Error	-0.3719	-0.3602	-0.0870	1.0000	-0.1820	-0.3151	0.4000
Depth Error	0.6408	0.2141	0.3762	-0.1820	1.0000	0.1742	0.3060
Insertion Depth	0.4454	-0.2285	0.6420	-0.3151	0.1742	1.0000	0.0835
Insertion Angle	0.4955	-0.4669	0.2095	0.4000	0.3060	0.0835	1.0000

Legend:
Important results
Correlation larger than 0.4

CONCLUSION

- Intuitive interface with in-situ guidance
- High accuracy with fast learning curve
- Promises of reduced X-ray dose and operation time
- Clinician stays in control and can revert to his/her usual procedure
- Inexpensive device

FUTURE WORK

- Controlled studies on human and animal cadavers
- MRI compatible version with the ability to display any slice in real-time

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