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MANGO: Low-Cost Open Source Needle Guidance

DAAD

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Background

- Context:
  a. intra-operative planning for percutaneous interventions
  b. validation of experiments
- Requires to localize the needle with a tracking system
- Most tracking systems are expensive for small labs
- Still requires accuracy compatible with targeted intervention
- Need for a cheap, open source, and accurate tracking system

Method

System design

- We introduce MANGO, a low-cost open source solution for needletracking
- Two webcams (Logitech C270 HD) mounted in a 3D printed case
- Colored orbs localised using stereo vision
  ➢orbs mounted on a structure attached to needle
  ➢color-based tracking using HSV
- Cameras calibrated using a Direct Linear Transformation (DLT)-like method as proposed by Zhang [1]
  ➢average reprojection error below 0.02 pixels

Figure 1: Left: the MANGO device. Center: the color orbs to track (front) and greyPolaris orbs (back) attached to a needle. Right: Tracked orbs circled in yellow

Validation protocol

- Comparison with an NDI Polaris Vicra system
  ➢Stated accuracy of 0.5 mm (CI-95)
  ➢Serves as a reference standard
  ➢Polaris orbs placed behind the colored orbs
- Place needle sequentially on a grid of points
  ➢points evenly spaced by 2 cm×2 cm
  ➢needle partly inserted in rigid foam to reduce oscillations
- Clustering time series of positions using DBSCAN [2]
  ➢Reference time vector used was 30 FPS

Figure 2: Left: validation setup to compare the MANGO with the NDI Polaris usinga two-faced marker fixture. Right: the needle is positioned precisely with thestyrofoam fixture

Results

- Oscillations due to: variations of light, movements in the background,cameras' auto-exposure feature (affected color tracking strategy)
  ➢Gaussian filtering
- RootMeanSquaredError(RMSE)andMeanAbsoluteError(MAE) below 5mm overall
  ➢RMSE and MAE lower than 2mm within the "optimal volume (red)"

	$RMSE_X$ [mm]	$RMSE_Y$ [mm]	$RMSE_Z$ [mm]	MAE_X [mm]	MAE_Y [mm]	MAE_Z [mm]
Static, full volume	2.72	0.68	4.47	2.25	0.55	3.60
Static, optimal volume	1.14	0.49	2.06	0.87	0.41	1.72
Dynamic, full volume	3.29	0.81	4.84	2.62	0.63	3.98
Dynamic, optimal volume	2.38	0.66	2.91	1.94	0.55	2.51

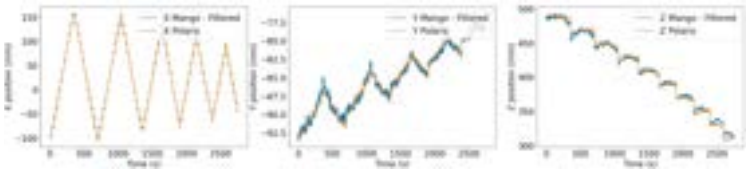


Figure 3: Comparison between the filtered data of MANGO and the data collectedwith the Polaris System

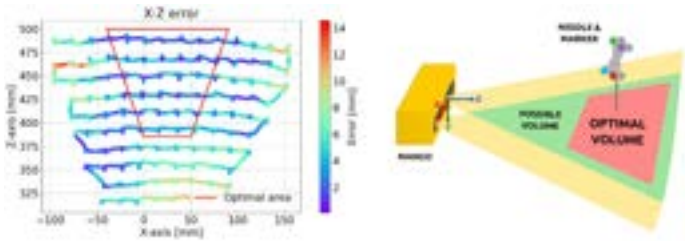
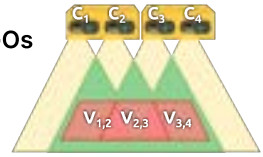


Figure 4: Left: Positional error of the MANGO in its x-z plane, the red trapezoid highlights the optimal tracking volume. Right: Illustration of possible and optimal tracking spaces.

Conclusion

- Code, data, 3D models released to provide a low-cost and reproducibleplatform for needle tracking in research environments
- Positional accuracy 5 mm usually required in percutaneous interventions
  ➢Orientational accuracy exceeded this margin
- We further aim to explore the potential ofcascading multiple MANGOs to increase thetracking volume and accuracy



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Acknowledgements

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