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Localization and Tracking with RF Coils that are Optically Detuned by the Control of an MR Compatible Manipulator

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Abstract

The aim of this work was to implement a technique for linking the manipulator maneuvering to the semi-active MR tracker coils so that, as the manipulator maneuvers, only a subset of MR trackers are used, and furthermore when this subset is tracked only one coil is active per MR acquisition cycle for unambiguous identification of the marker. With this manipulator-driven technique, tracking the interventional tool requires a lower number of MR acquisitions and additional post-processing is no longer required. Studies were performed on-the-bench to test the performance of the computational aspect of the framework in regard to latency and generation of the appropriate commands for controlling the MR marker visibility, and in the MR scanner on a phantom to assess the manipulator-driven changes of the MR visibility of the MR trackers.

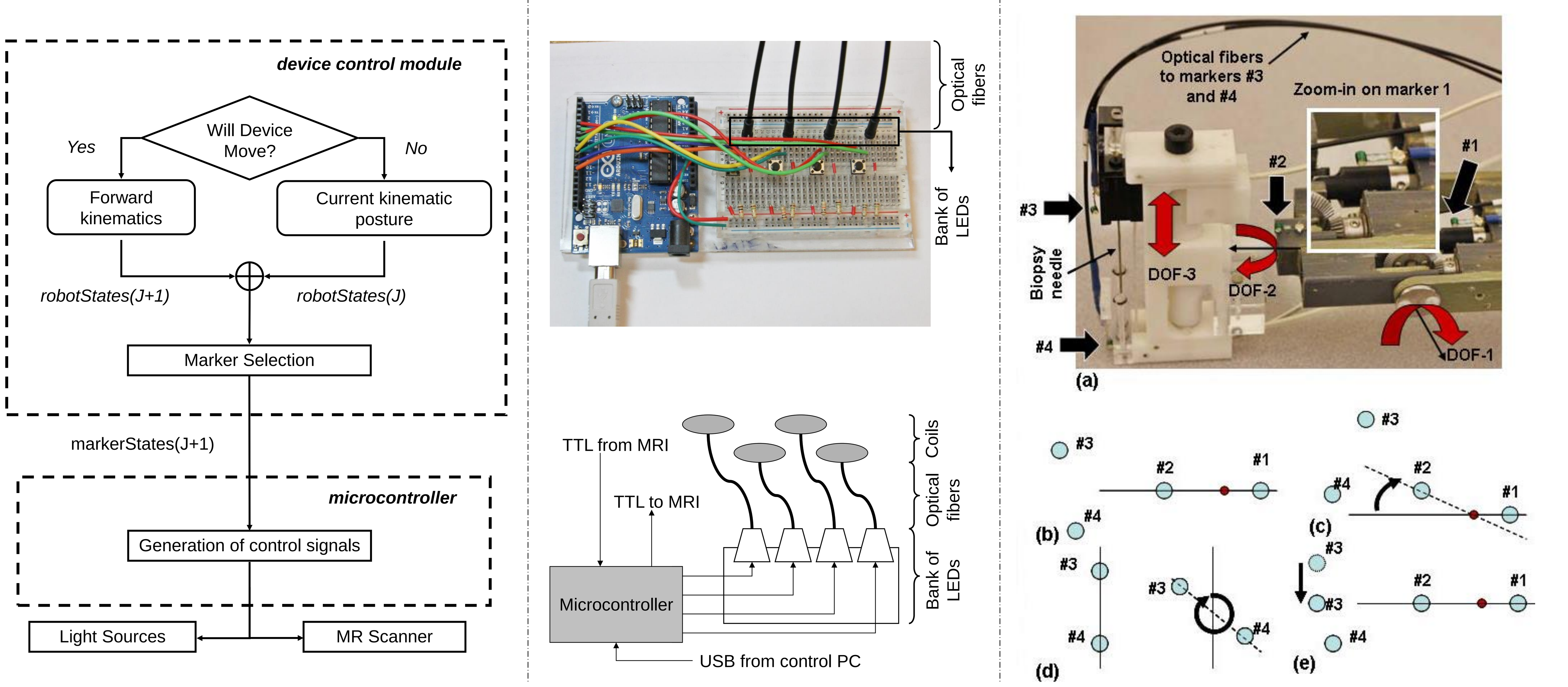
INTRODUCTION

To register and track interventional tools, several types of MR markers have been described including fiducial markers made of active RF coils connected to a dedicated channel of the scanner, semi-active inductively coupled RF coils or passive signal sources. Measuring the position of these coils relative to the coordinate system of the MR scanner can be performed with 1D projections or 2D imaging. Depending on the kinematic structure of the interventional tool, multiple such fiducial markers may be needed for tracking the tool in three-dimensions. When multiple passive or semi-active markers are used, it is important to unambiguously associate the received signals with the particular marker that generates them. Previous approaches include the collection of multiple 1D projections and post-processing algorithms to identify the associated markers and signals. Alternatively, markers may be shaped in a specific geometry in order to measure the position and orientation of the tool: this approach, however, requires appropriate post-processing software for extracting this information. In order to unambiguously distinguish semi-active markers a simple approach would be to selectively detune all but one per acquisition by using optical detuning.

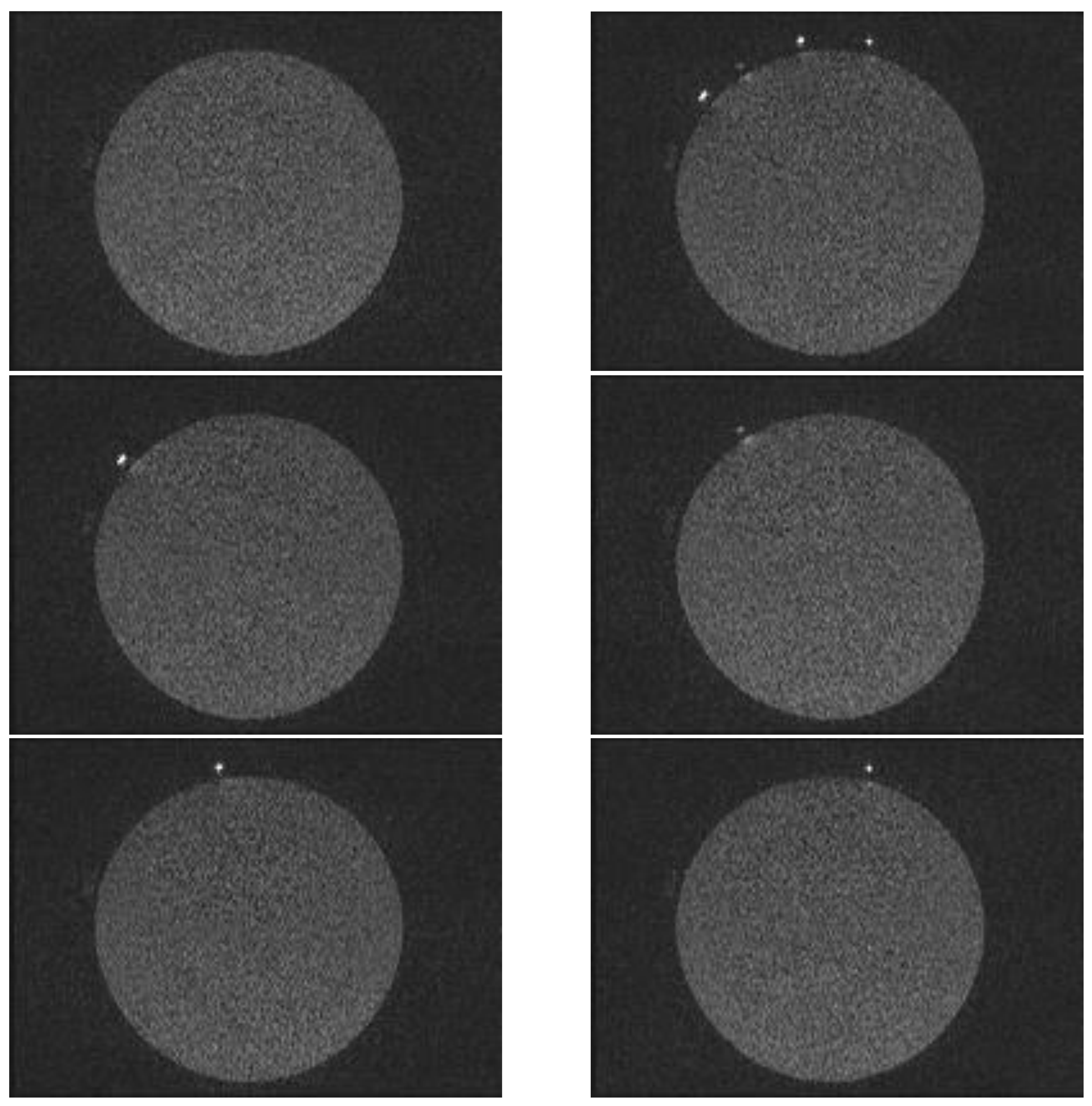
METHODS

Manipulator-Driven Tracking

When computer controlled manipulators or tools are used, a solution to speed up acquisition and eliminate post-processing is to link the manipulator control to semi-active markers and selectively detune them. This will allow a subset of markers is MR visible since those are needed to track the maneuvering portion of the device. Further, only one marker can be MR visible per acquisition cycle thus the coils are unambiguously identified.



EXPERIMENTAL RESULTS



	Marker ($\mu \pm \sigma$)	Background ($\mu \pm \sigma$)	Phantom ($\mu \pm \sigma$)
Tuned (visible)	3178.33 ± 1005.43	632.25 ± 68.42	1327.99 ± 224.64
Detuned (invisible)	689.20 ± 87.00	633.08 ± 72.12	1371.38 ± 203.09

(μ: mean, σ: standard deviation)

DISCUSSION AND CONCLUSION

We introduce a technique for linking robot control and MR marker visibility for robust localization and fast tracking. Selecting which markers are visible based on the motion of the robot allows quicker MR tracking since only certain markers need to be visible. In addition, by tuning only one marker per acquisition repetition, the location of this particular point of the instrument is unambiguously identified simplifying data acquisition and post-processing.

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