Fast Tracking of MR Compatible Robots with Computer-Controlled Optically Detunable Inductively Coupled RF Coils

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BACKGROUND

Robot-Assisted Surgery
▶ Safety
▶ Quality
▶ Time and cost
▶ Less invasiveness
▶ Accuracy and precision

MRI-Guided Intervention
▶ MRI offers :
  ‣ Excellent soft tissue contrast
  ‣ Multi-slice, multi-planar
  ‣ No harmful ionizing radiation
  ‣ On-the-fly adjustment view plane
▶ MRI-Guided Interventions:
 ‣ Preoperative & intraoperative 3D images
  ‣ Intraoperative manipulations

Challenges in MRI Robotic Surgery
▶ High strength magnetic fields
  ‣ Standard field strength
    ‣ 1.5 T or 3 T
▶ Localization and tracking
  ‣ MR-visible markers
▶ Patient accessibility
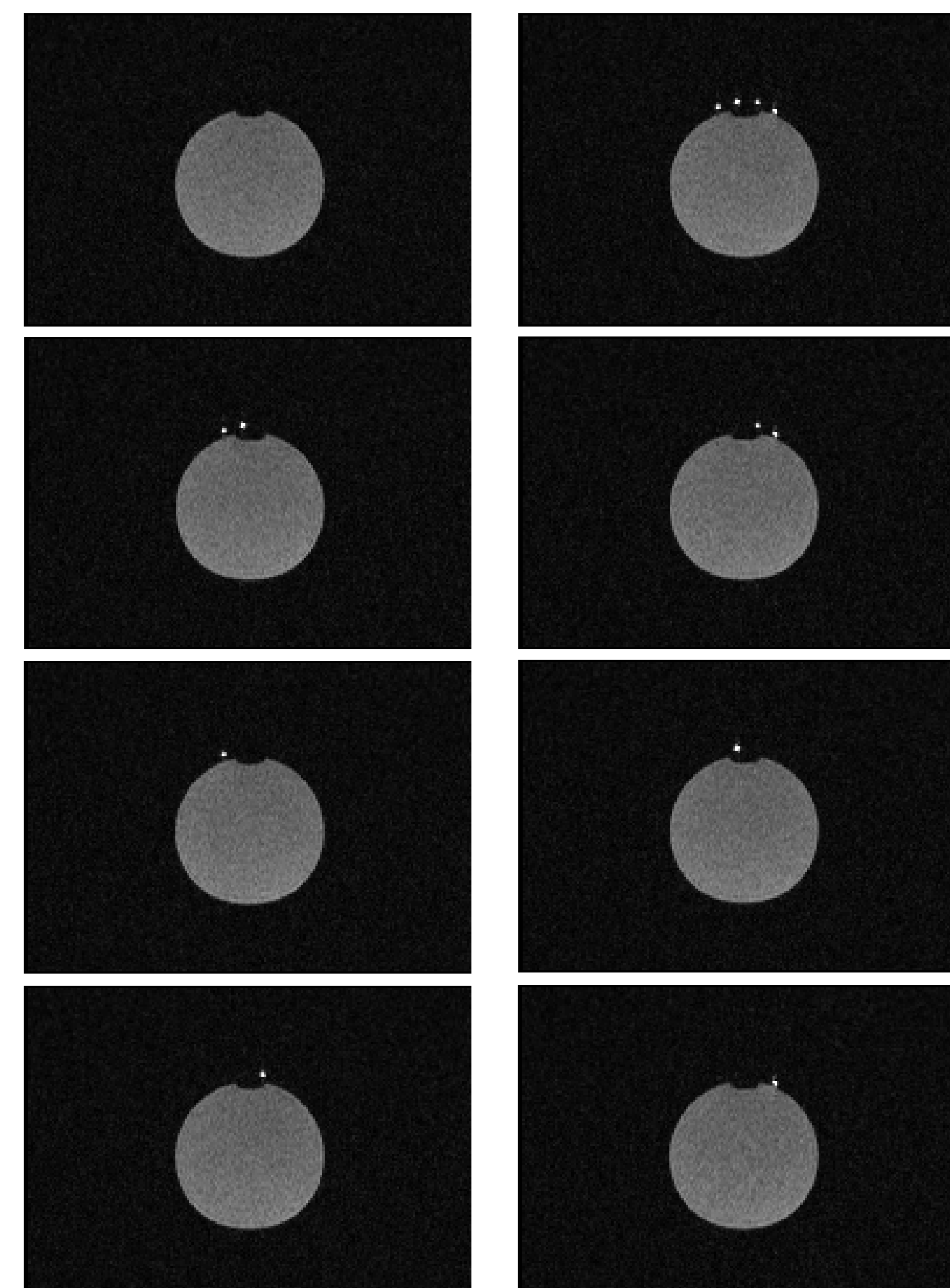 ‣ Magnetic bore encompasses the patient

INTRODUCTION

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.
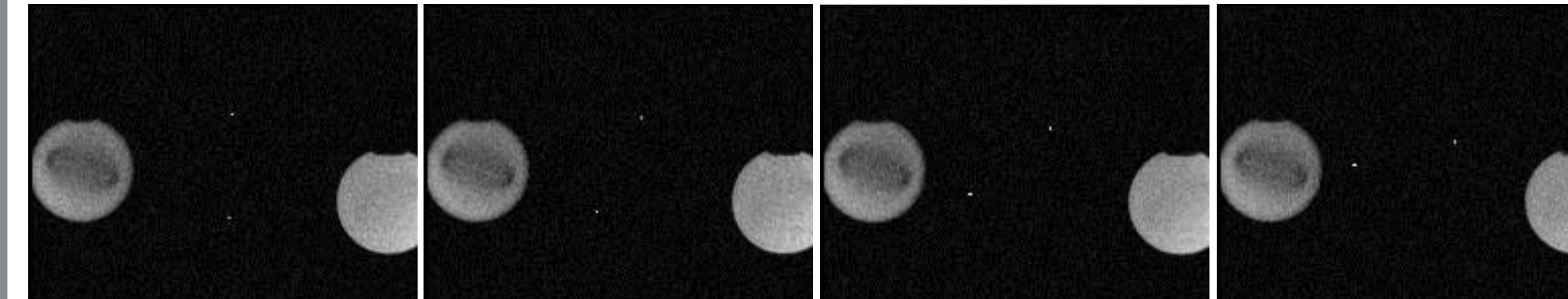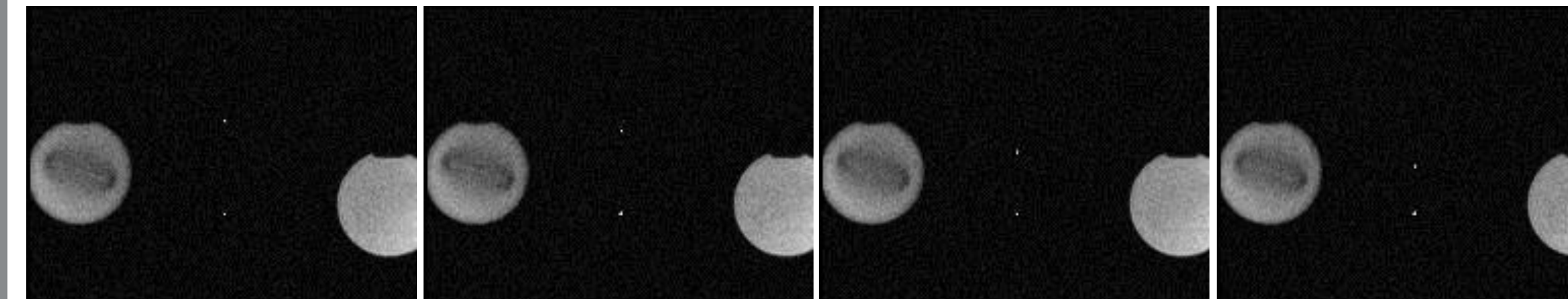
METHODS
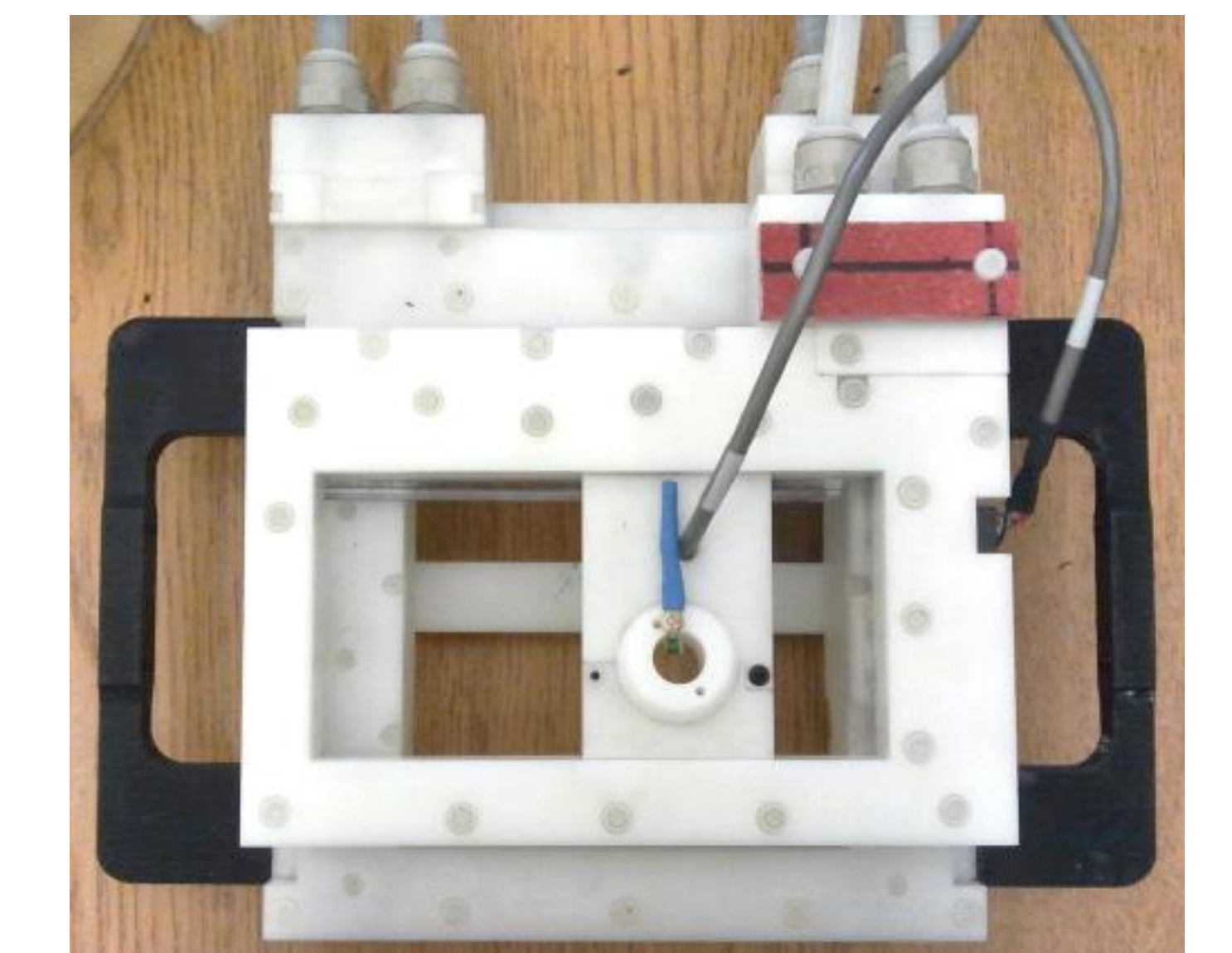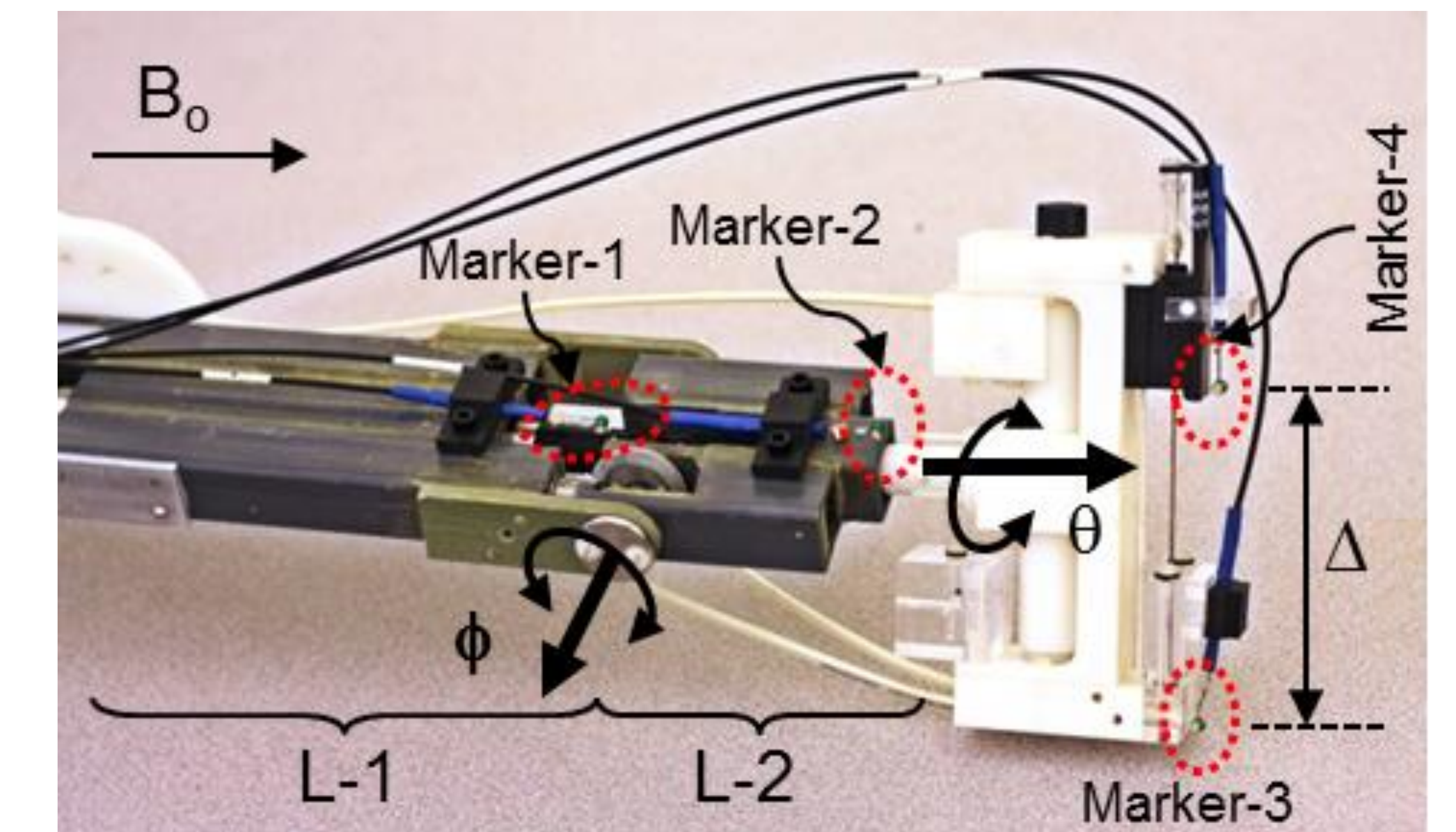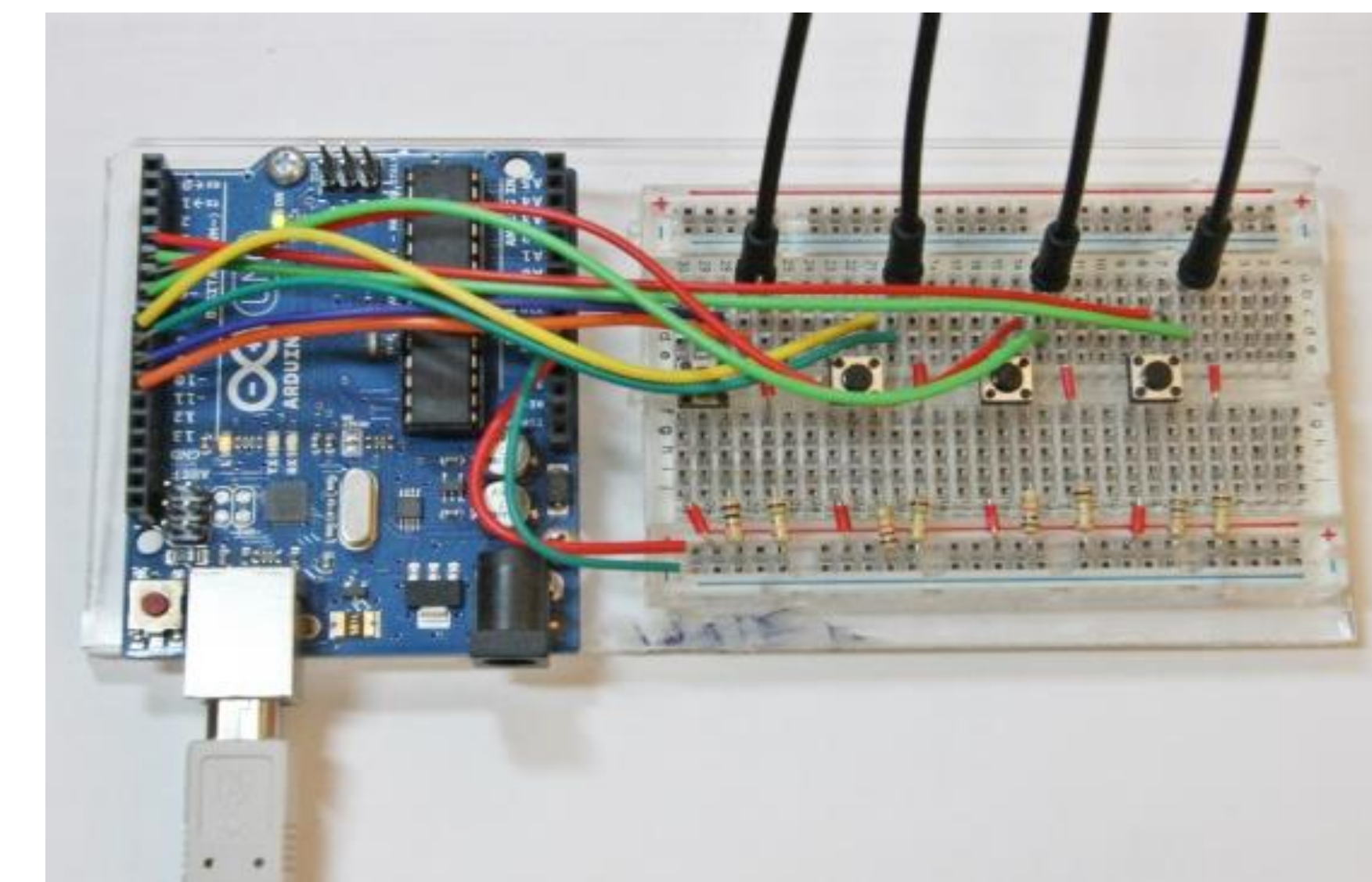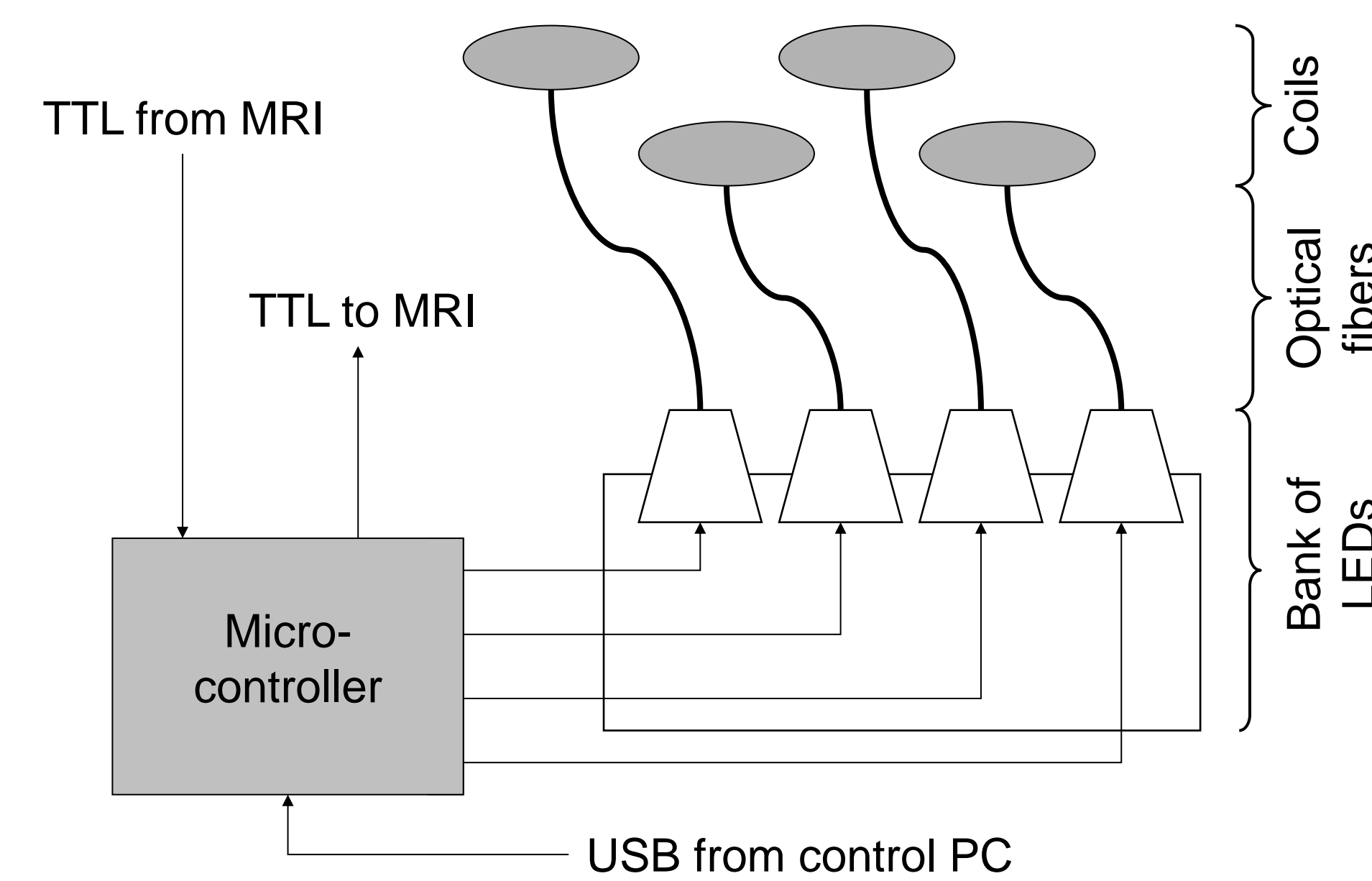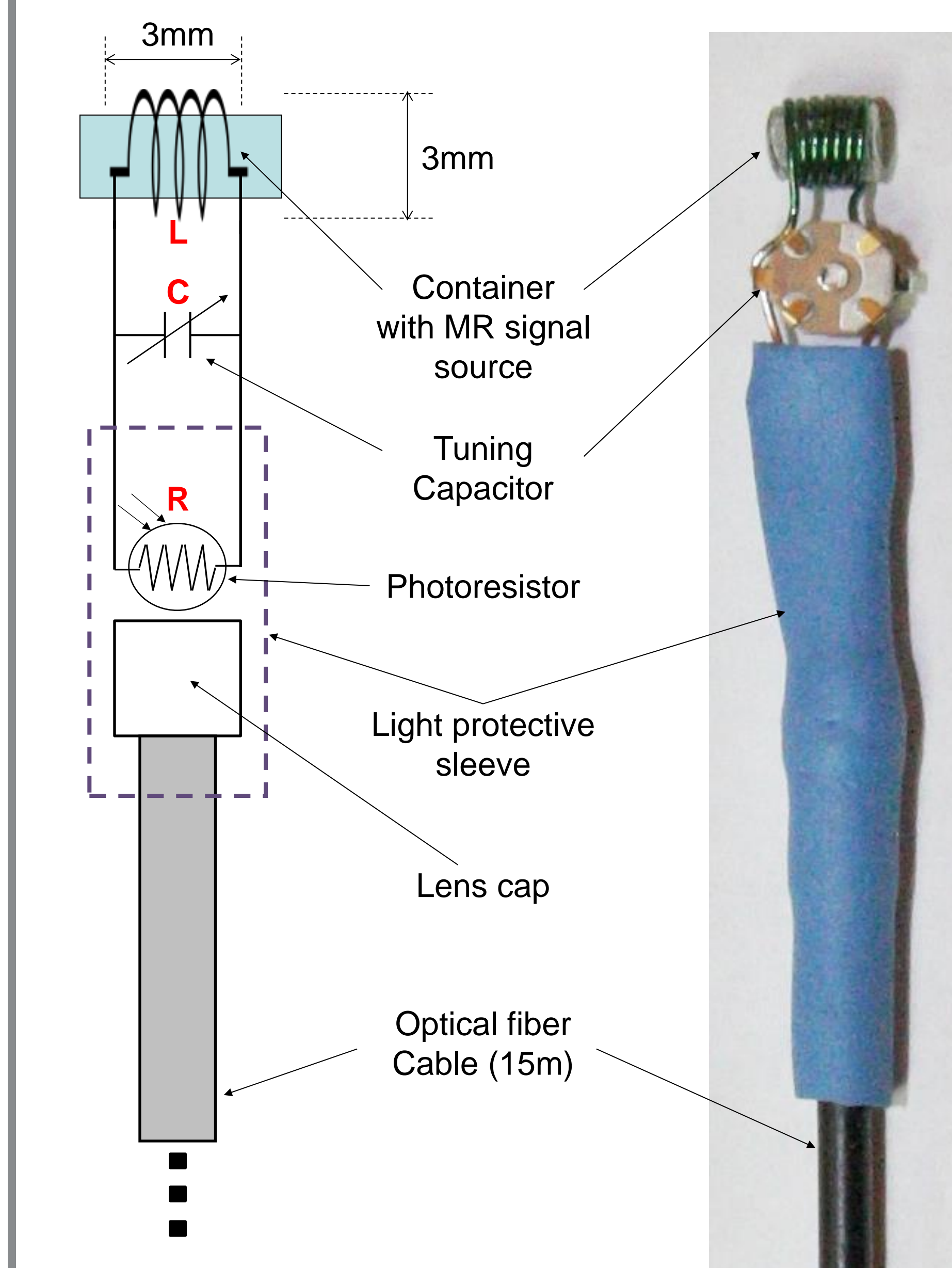
EXPERIMENTAL RESULTS
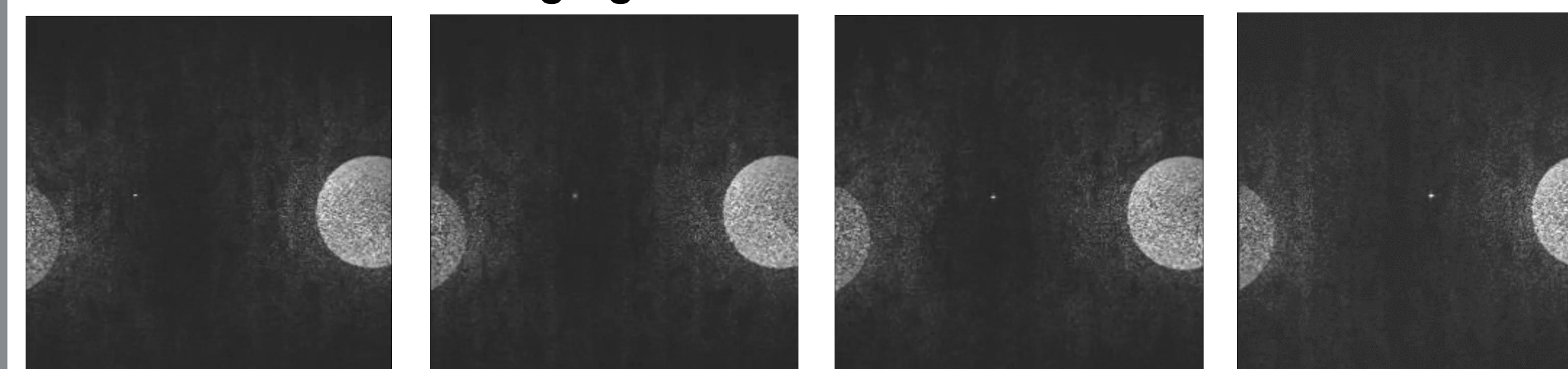

- Optically tuned and detuned MR visible markers
- DoF-2 rotating the end-effector counterclockwise
- Prismatic DoF-3 translating the end-effector
- Transverse MR imaging with a marker

	Markers (μ ± σ)	Background (μ ± σ)	Phantom (μ ± σ)
Tuned (visible)	114.21 ± 13.97	5.94 ± 1.88	42.31 ± 1.74
Detuned (invisible)	6.33 ± 1.59	6.13 ± 2.58	44.19 ± 3.90

(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 speeding up of 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.

REFERENCES

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[2] Junmo An, Andrew Webb, Ioannis Seimenis, Eftychios Christoforou, Nikolaos V Tsekos, "Tracking of MR compatible interventional robots by controlling the MRI visibility of optically detunable MR markers", Physica Medica: European Journal of Medical Physics, 2014.

ACKNOWLEDGEMENTS