Real-Time Position Tracking of Medical Devices by analyzing Changes in a Magnetic Field at Pre-Determined Points

Mohammad Odeh1

Edward Daniel Nichols1

Fluvio Lobo1

Jack Stubbs1

Institute for Simulation and Training,

University of Central Florida1

# 1 Background

As the demand for increasingly advanced invasive medical procedures rises with the average age of the population, it also becomes increasingly compelling to facilitate and extend the spatial awareness and dexterity of surgeons, both human and robotic. One may accomplish this by tracking an object digitally and representing its motion in a virtual representation of the area around the incision. Several groups across a diverse range of academia and industry have competed to develop better and better methods of digitally tracking objects [CITATION HERE]. In the entertainment industry in particular, object tracking is a fundamental way of bringing life-like motion to an object represented in virtual space. The generally accepted approach is to use large, complicated, and expensive computer vision (CV) systems to yield real-time tracking [CITATION HERE]. However, this approach is not suited for medical applications; CV is limited by a strict field of view. Accurately tracking surgical instruments inside of organic tissues must then be done another way.

Of the methods investigated by others [CITATION HERE], none are as demonstrably effective, or applicable in a medical context as magnetic field sensing. Human tissues are permeable to magnetic flux, and magnetic fields are well characterized. Upon this motivation, we have constructed a low cost device that enables the tracking of a permanent magnet on a planar surface to serve as a foundation for future work in this field.

# 2 Methods

Electromagnetic fields are well characterized by fundamental principles. Given a magnetic dipole, its magnetic induction can be expressed as:

|  |  |
| --- | --- |
|  | (1) |

Whereby the relationship is dependent on the orientation of the magnet and the strength of its magnetic moment, given by , as well as the location of the arbitrary point of interest with respect to the center of the magnet, represented by . Equation (1) can be modified to express the strength of the magnetic field **,** which is what an observing magnetometer would perceive; which may further be broken into a more convenient polar component form:

|  |  |
| --- | --- |
|  | (2) |
|  | (3) |

This

* Outline of analytical foundations
  + Fundamental concepts on EMF
  + Identify constraints/assumptions
  + Deriving a value of “K” for an arbitrary magnet
  + Empirical approx. of K
* Summary of system iterations and design inspirations.
* Exhaustive explanation of devices and system configuration.
  + A nice “Fig. 1”
* Explanation of computational approach
  + Identify key libraries and modules
  + Newton-Raphson Method
  + Optimization approach

See the “Writing a Technical Paper or Brief” section, under Guidelines at the ASME Journal Tool Author Help ([**http://tinyurl.com/43chze9**](http://tinyurl.com/43chze9)) for handling mathematics, equations, figures and tables.

# 3 Results

* Examples of data plot
* Speed of the data
* Accuracy and precision
* Discuss permeability of materials to magnetic flux

The Results section describes the evaluation of the design or the experimental methods.

# 4 Interpretation

The Interpretation section provides an interpretation of the results and conclusions of the study.

* Limitations of the approach
  + Fixed Initial Position
* Other calibration considerations

.

# References

References follow ASME style, described in See the “Writing a Technical Paper or Brief” section, under Guidelines at the ASME Journal Tool Author Help (<http://tinyurl.com/43chze9>)

* All references need to be complete citations with ALL authors listed (As per style et al. is not allowed in the reference list.), starting page number and ending page number, doi if available, etc. **examples:**
  + Brigitte, M., Max, S., Juergen, H., Peter, M., Bernd, K., & Eckhart Georg, H. (1999). Disposable-sheath, flexible gastroscope system versus standard gastroscopes: a prospective, randomized trial. Gastrointestinal Endoscopy, 50461-467. doi:10.1016/S0016-5107(99)70066-0
  + Ma, J. and Kim, H. M., 2014, “Continuous Preference Trend Mining for Optimal Product Design With Multiple Profit Cycles,” J. Mech. Des., 136(6), 061002, doi: 10.1115/1.4026937

[FORMATTING NOTES]

* Entire paper is two to four pages. Top and bottom page margins are one inch so that total text height is 9 inches. There are two columns, with the title area being in the first column. Columns are 3.125 inches wide and the spacing between the two columns is 0.25 inches for a total text width of 6.5 inches. Columns are justified left and right.
* Font for title, headers, body text is Times. Body text is 9 point. Title is 14-point bold. Authors and affiliation are 11-point with author names in bold..
* New paragraphs are indented by 0.2 inches, no blank line between paragraphs.
* There are no page numbers.
* Provide definition for all acronyms. Example: deep brain stimulation (DBS)
* When in doubt, look at an article in an ASME journal.