WELLTEC

Welltec is a world-wide service company in the oil and gas sector with 34 offices in 16 countries. We provide channeling and intervention methods for oil and gas drilling, based on the world patented Well tractor technology. The company has a world market share of more than 70% with key clients being Exxon, Statoil, Chevron etc.

The R&D department has a 500m^2 test facility and a 200m replica of a horizontal oil well which is used for testing. Welltec has one of the most advanced production facilities in Denmark with integration from 3D CAD to 3D CAM on multi axis CNC machines. With quality as a strategical objective, Welltec has introduced standards from aerospace production, installation and servicing with constant improvements in production and assembly as a goal.

DISTANCE AND DIRECTION USING MEASURED MAGNETIC FIELD VECTORS

The basic objective of this ESGI problem is to locate a magnetic dipole in space and determine the direction of a given axis, e.g. the magnetic moment. This is to be done, using measurements of the magnetic field at different positions.

There are two different setups to work with:

1. **Rotating magnet:** The magnetic field rotates around an axis perpendicular to the magnetic moment, with the magnet centered on the axis of rotation. The position of the magnet, and the direction of the axis of rotation are the desired outputs.
2. **Stationary magnet:** Determine the position of the magnet and the direction of the magnetic moment.

In both cases, a number of sensors, each providing a 3-axis magnetic field strength measurement, are distributed at known positions along a straight line.

MODEL

It is assumed that the distance between magnet and sensors is sufficiently large, such that a model of a theoretical magnetic dipole is able to approximately describe the field at the sensors. For a magnetic dipole placed at the origin with the moment directed along the positive z-axis, the model is (in Cartesian and spherical coordinates respectively):

$$B_x = \frac{xz}{r^5},$$
$$B_y = \frac{yz}{r^5},$$
$$B_z = \frac{z^2 - \frac{1}{3}r^2}{r^5},$$

or

$$B_r = \frac{2\cos\theta}{3r^3},$$
$$B_\theta = \frac{\sin\theta}{3r^3},$$
$$B_\varphi = 0.$$

A common factor of $\frac{3\mu_0\mu}{4\pi}$, proportional to the strength μ of the magnet, has been omitted from all the above expressions.

CURRENT PROGRESS

Based on the model above, equations for determining the position of a rotating magnet (Setup 1) have been developed, for the special case where the axis of rotation is known. These equations have been confirmed by experiments with a prototype system. Also, a method for Setup 2 has been developed, but remains to be tested and confirmed.

So far, no work has been done on the uncertainty/sensitivity of the methods.

PROBLEM STATEMENT

Given the setup of the magnet (stationary/rotating/pulsating) and sensors (quantity/relative positions etc.), provide a method for determining the position of the magnet and the direction of the magnetic moment/axis of rotation. Furthermore, an estimate of the uncertainty of the estimate is desirable, given the setup and the characteristics of the sensors.