Optimal Sensor Design and Fabrication

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Motivation

An abnormal accumulation of cerebrospinal fluid (CSF) leads to a condition known as Hydrocephalus. Over 150,000 people are diagnosed with this disease in the U.S. each year.

The current treatment method for all types of Hydrocephalus incorporates an intracranial pressure based shunt.

Frequent problems encountered with long-term intracranial pressure based shunts include:

- Under-drainage or Over-drainage possibly leading to fatality
- Multiple shunt revisions which require surgery
- (The average lifespan of a shunt is five years)
- For adults: Complication rate = 35%

Solution Approach:

- Produce constant electric vector field via excitatory electrodes.
- Changes in the electric field distribution occur with changes in volume.
- Dependent on CSF and brain tissue electrical conductivity differences.
- We have verified and implemented the principle on benchtop models [2].

Computer Aided Sensor Design

- MRI from external collaborators [3] or patient specific images are reconstructed into 3D models (MMICS)
- Sensor is modeled with variable parameters
  - Image Reconstruction and 3D modeling
  - Based FEA simulation

Sensor Optimization

- Finite Element Simulation to analyze design
- CAD of sensor
- FEA with design
- CAD files are exported to FEA software (ADINA) for simulation and analysis.
- Static simulations are performed with a normal size ventricle and enlarged ventricles based on patient data.
- Dynamic simulations track the change in electric field distribution and provide knowledge of intracranial dynamics.

Conclusions and Future Directions

Promising experimental and simulation results show that the conductance-volume relationship for Hydrocephalus patients can be used as a treatment option.

Future Directions include:

- Performing rigorous simulations to assess multiple sensor configurations and obtaining optimization algorithm for sensor design.
- Acute animal experiments to validate principle in physiological systems.
- Develop advanced sensors, including pressure measurements.
- Perform long term in vivo study in animal models.

References


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