Bear (1884) “Telegraphing Without Wires” — Simulator & Dataset (v1.0)

1. Overview

This dataset provides a computational reconstruction of S. J. M. Bear’s 1884 experiment on conduction-based signal transmission through water. The dataset contains field simulations, receiver modeling, and time-domain keying behavior generated via a finite-difference solution of the variable-conductivity Laplace equation.

The goal is to reproduce and analyze early “wireless” communication through conductive media using modern computational methods.

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2. Dataset Structure

Each experiment configuration generates three primary file types:

A. Field Data (NPZ)

Files: `*_fields.npz`

Contains:

- `sigma` – spatial conductivity map
- `V_tub_1V` – normalized potential distribution
- `V_delivered_no_pol` – delivered potential without polarization
- `V_delivered_pol` – delivered potential with polarization
- `Ex`, `Ey` – electric field components
- `Jx`, `Jy` – current density components
- `Emag`, `Jmag` – field magnitudes
- Electrode masks (`tx_plus`, `tx_minus`, `rx1`, `rx2`)

B. Time Series Data (CSV)

Files: `*_timeseries.csv`

Columns:

- `t` – time (seconds)

- `key` – transmitter key state (0/1)
- `Vpol` – polarization voltage
- `Vtub` – delivered tub voltage
- `Isource` – source current
- `Vth` – Thevenin receiver voltage
- `Irelay` – relay current
- `relay_state` – relay actuation state (0/1)

C. Experiment Summary (JSON)

Files: `*_summary.json`

Contains:

- Configuration parameters
- Thevenin equivalent parameters (Vth_per_1V, Rth)
- Tub resistance estimate
- Relay activation thresholds
- Delivered voltages and currents
- Relay click indicators

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3. Experiment Variations

The dataset includes multiple conductivity scenarios:

- Baseline uniform saltwater
- Uniform freshwater
- Uniform brine
- Half freshwater / half brine interface
- Insulating obstacle
- Conductive wire-in-water path
- Brine plume near receiver
- Sensitive relay configuration
- Increased transmitter–receiver separation

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4. Computational Method

The potential field is computed by solving:

$$\mathrm{div}(\sigma \nabla V) = 0$$

using a finite-difference discretization with harmonic averaging of conductivity at cell boundaries.

Receiver modeling is performed using a Thevenin-equivalent formulation derived from the simulated field response. Time-domain behavior includes simple electrode polarization dynamics and relay threshold modeling.

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5. Reproducibility

All data were generated using the provided Python script:

```
Bear-1984-v1.0.py
```

Dependencies:

- numpy
- scipy
- matplotlib

Running the script reproduces all experiments and outputs.

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6. Intended Use

This dataset may be used for:

- Study of signal propagation through conductive media
- Historical reconstruction of early wireless experiments
- Field-based communication modeling
- Education in electrostatics and applied electromagnetics
- Finite-difference PDE modeling demonstrations
