# Heterogeneous Robotic Large-Scale Seismic Sensing

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***Abstract*— Traditional seismic surveying employs human laborers for sensor(geophone) placement and retrieval. Use of explosives, harsh climatic conditions, high costs and time associated with human deployment are the major drawbacks of traditional surveying. We propose an autonomous heterogeneous sensor deployment system. Simulations and hardware experiments were performed to prove the effectiveness of automation in terms of cost and time. A detailed analysis and comparison with tradition surveying was conducted. The performance of the proposed system was on par with the traditional system. It also overcomes the drawbacks and displayed higher efficiency, thus proving the proposed system has great potential to replace traditional systems.**

## I. Introduction

Seismic surveying is a geophysical technique involving sensor data collection and signal processing. It aims at identifying and retrieving hydrocarbons like coal, petrol, natural gas. Traditional seismic surveying involves manual laborers placing geophone sensors at specific locations connected by cables. Cables are bulky and the amount required is directly proportional to the area surveyed. On an average hundreds of square kilometers would be surveyed and miles of cabling is required. Seismic surveying is done at remote locations and problems like accessibility, harsh conditions and especially transportation of bulky cables and sensors phenomenally increases the cost. Nodal sensors are autonomous units that do not require bulky cabling. They have an internal seismic recorder, which is basically a micro-controller that controls and records seismic readings. This technology gets rid of bulky cabling and there by reduce the overall cost. Currently nodal sensors are becoming popular at USA due to reduced costs in seismic sensing.

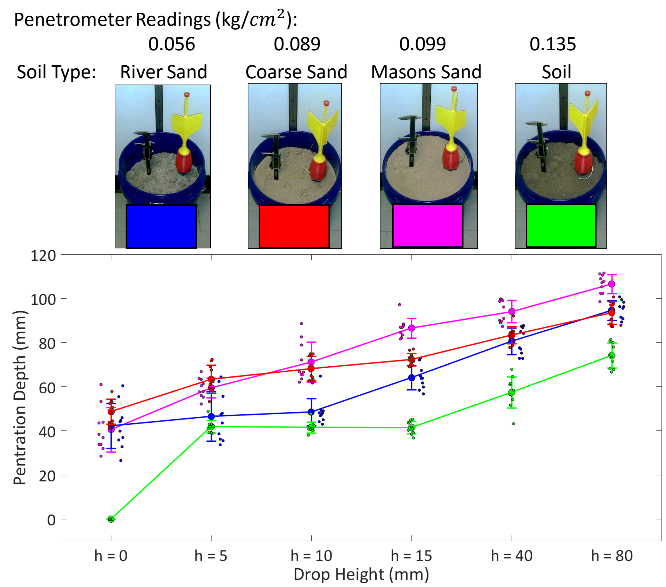


Fig. 1: Graph compares drop height vs penetration depth in four different soils types.

## II. Overview and Related Work

### A. Seismic Sensing

### B. Sensor networks

### C. Multi-Robot Assignment

## III. Smart Darts

### A. Design

### B. Experiments

#### 1) Exp 1: Drop tests in different soils

Drop tests as function of soil type, depth and angle

#### 2) Exp 2: Straight vs Bent Fins

Drop tests as function of height, compare twisted vs straight tail, depth and angle

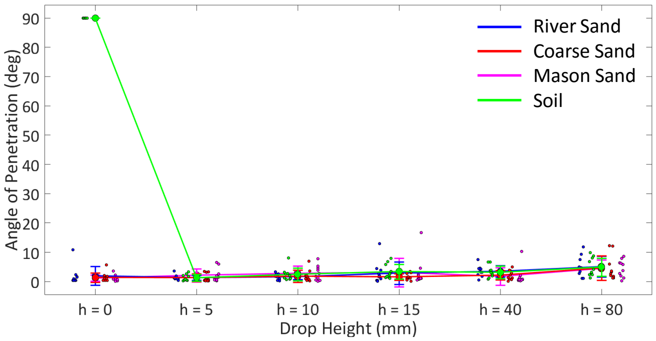


Fig. 2: Graph compares drop height vs angle of deviation in four different soils types.


Fig. 3: Outdoor Drop test comparing Straight vs Bent fins performance.a.) A smart dart being dropped b.) The drop height is measured

#### 3) Exp 3: Autonomous drop

Exp 3: Automatic drop from drone, accuracy in placement

#### 4) Exp 4: Shot gather comparison

Exp 4: Dart sensing accuracy vs ground setup

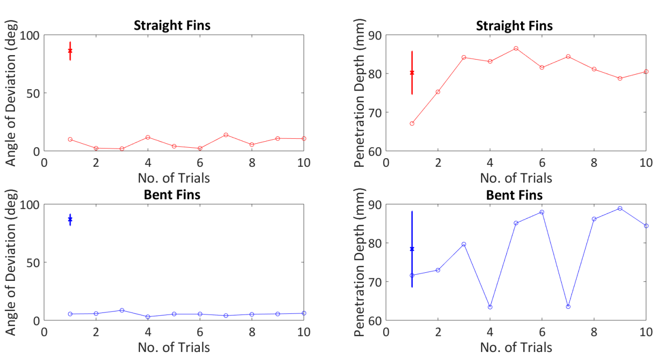


Fig. 4: Straight vs Bent fins comparison. The penetration depth and angle of deviation was compared. Fixed drop height of 9.8 m was usd for the experiment.

## IV. SeismicSpider

### A. Design

### B. Experiments

#### 1) Exp 1: Accuracy plot

Hexapod move to desired GPS location (plot accuracy)

#### 2) Exp 2: Shot gather comparison

Hexapod sensing accuracy vs ground setup

#### 3) Exp 3: Deploying and Retrieving Hexapod

Exp 5: Retrieving Hexapod

## V. DeploymentUnit(UAV)

### A. Design

### B. Experiments

## VI. Comparision

## VII. Conclusion and FutureWork