ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

SWIS

Earthquake detection with e-pucks

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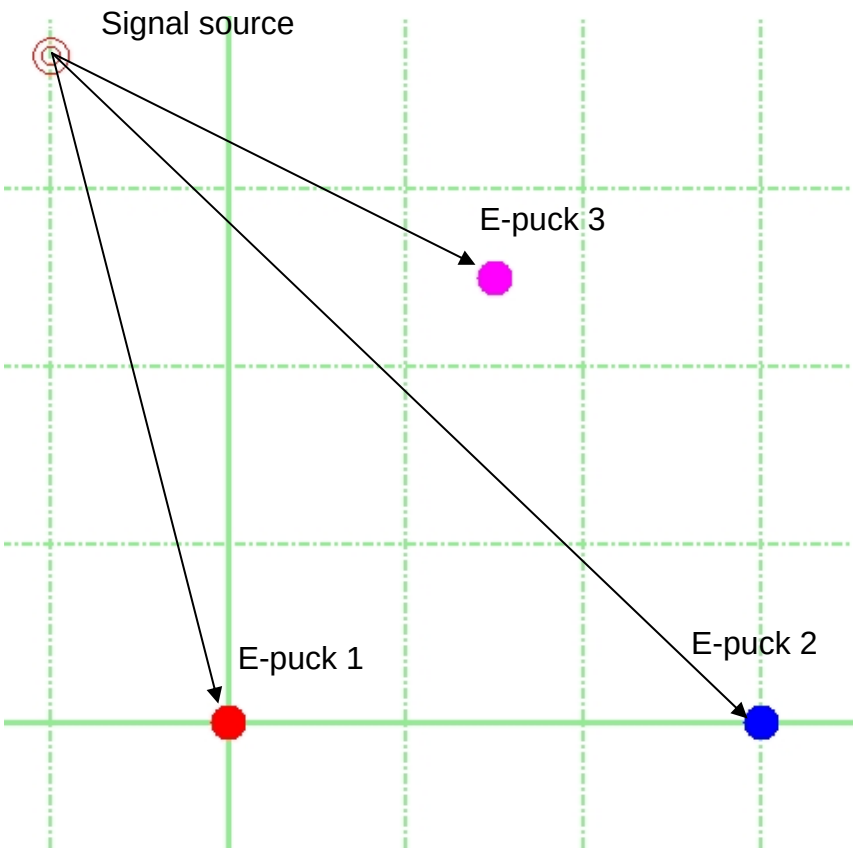
Multilateration



- Model to approximate the position from TDOA
- TDOA = time difference of arrival
- 3 e-pucks are sufficient for finding 2D position

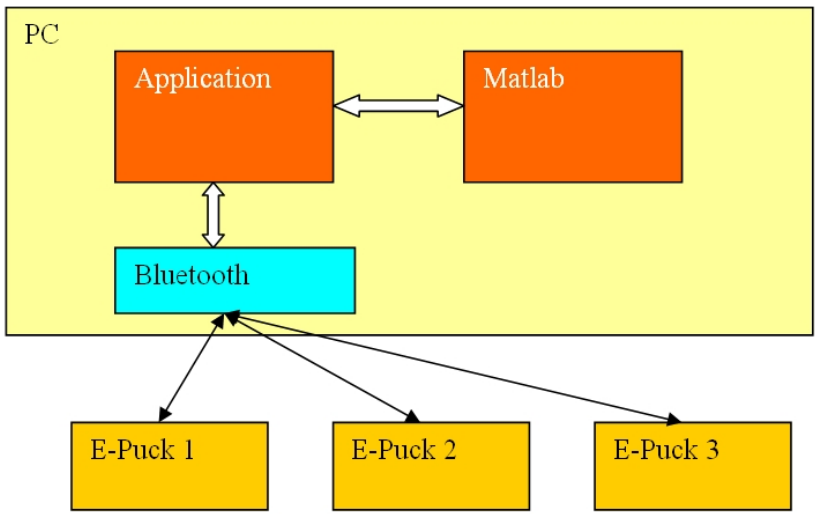
Initial equations

- (x, y): coordinates of signal source
- (x1, y2): coordinates of e-puck 1
- t1: time of arrival (TOA) at e-puck 1
- c: signal velocity

$$ct_1 = R_1 = \sqrt{(x_1 - x)^2 + (y_1 - y)^2}$$
$$ct_2 = R_2 = \sqrt{(x_2 - x)^2 + (y_2 - y)^2}$$
$$ct_3 = R_3 = \sqrt{(x_3 - x)^2 + (y_3 - y)^2}$$

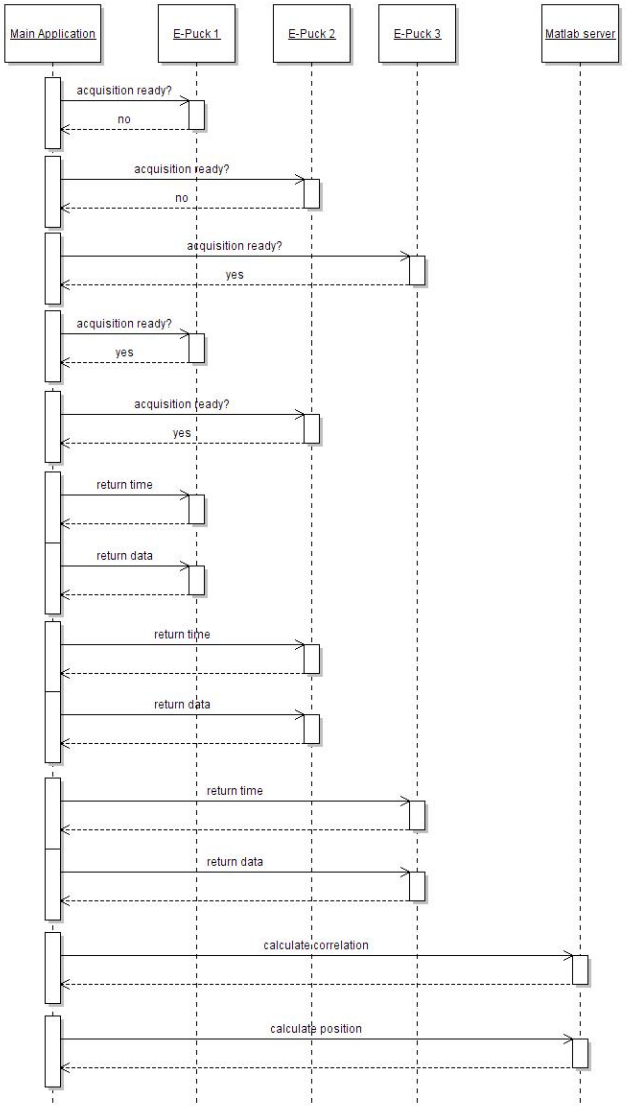
$$R_1 - R_2 = R_{12} = \sqrt{(x_1 - x)^2 + (y_1 - y)^2} - \sqrt{(x_2 - x)^2 + (y_2 - y)^2}$$
$$R_2 - R_3 = R_{23} = \sqrt{(x_2 - x)^2 + (y_2 - y)^2} - \sqrt{(x_3 - x)^2 + (y_3 - y)^2}$$
$$R_3 - R_1 = R_{31} = \sqrt{(x_3 - x)^2 + (y_3 - y)^2} - \sqrt{(x_1 - x)^2 + (y_1 - y)^2}$$

Architecture



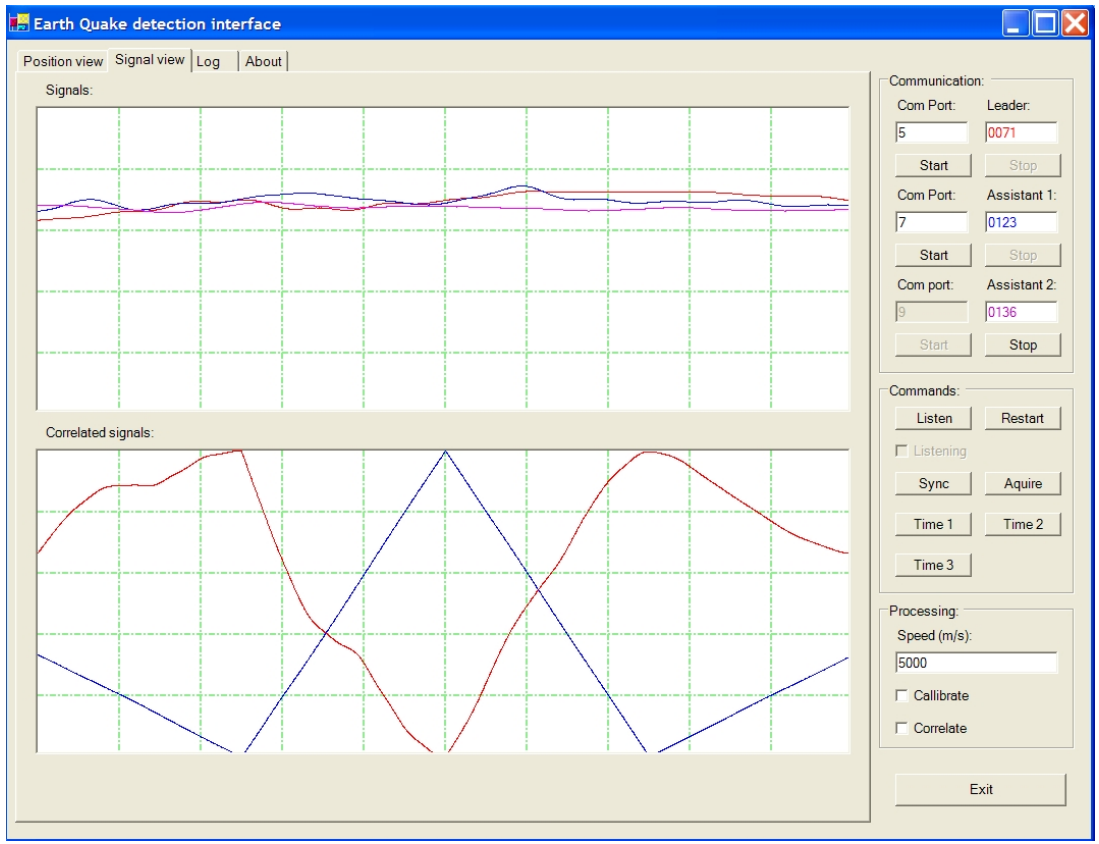
- Centralized
- Master-Slave architecture:
  - Master: Application
  - Slaves: E-pucks (intelligent sensors)
- Arbitration by sequencing

Communication



- Polling to find out when acquisition is complete
- Data retrieved in sequence
- Data processed in Matlab

Application interface



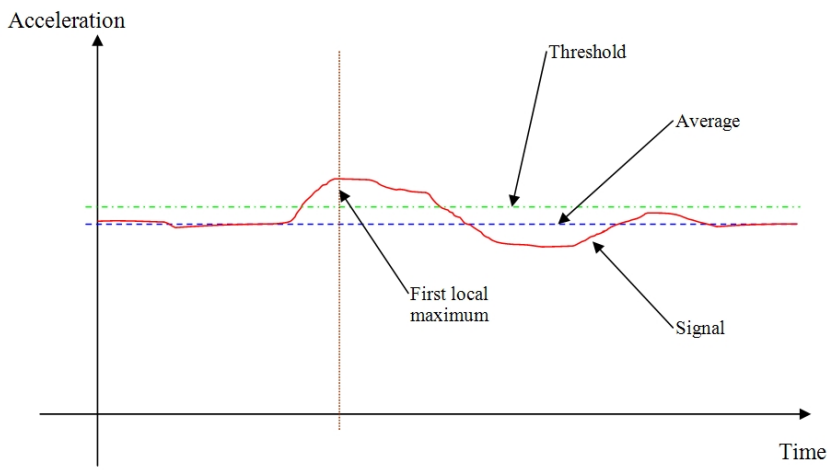
- Visual Basic .Net application

Synchronization

- Flash: Infrared sensors exceeds threshold
  → Reset internal clock
- 64-bit internal clock reference (no overflow problems)

- Demo

Peak detection



- Adaptive threshold
- Detect first local maximum above threshold
- Record and transmit 1280 samples (25% before the peak, 75% after)
- Demo

Results

- Hardware restrictions: Accelerometer is too slow and filters frequencies above 150 Hz
- Mathematical framework simulated and tested in Matlab

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Thank you for your attention.

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