LIMITATIONS OF THE E-PUCK ACCELEROMETER TO DETECT EARTHQUAKES

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Presentation

- Goal of the project
- Experiments: Webots & e-puck
- Results: Webots & e-puck
- Discussions: Webots & e-puck
- Videos
- Limitations
- Conclusion
Goal of the Project

• Detect earthquake with the three-axis accelerometer of the e-puck robot

• Questions to answer in the project:
  – Is the e-puck capable to spot S-wave and P-wave?
  – Is the e-puck able to detect earthquake with a good accuracy?
  – What are the factors, which limit the accuracy of the detection?

• Interest in the research to use cheap sensors to detect earthquakes or even locate the epicenter with a network of sensors
  – Example of research: Nathan Evans, Jean-Christophe Fillion-Robin, Robust earthquake detection using e-pucks, Communication Systems Faculty, EPFL Lausanne
Experiments on Webots

- The e-puck under simulates an earthquake
- The e-puck above has to detect when the earthquake happens and to print a message
Experiments on the e-puck

• The iPhone simulates an earthquake by vibrating

• The goal is to implement an earthquake detection on the e-puck and turn on the LED when it happens
Two methods of implementation
Filter on Fdatool

- Fstop1 : 19
- Fs : 100
- Fpass1 : 20
- Wstop1 : 3
- Fpass2 : 25
- Wstop2 : 1
- Fstop2 : 26
- Wstop3 : 1

Sampling at not so high frequency mean filter design is easier.

Remove parasites where they are!
Results in Webots
Results in Webots

<table>
<thead>
<tr>
<th>[e-puck_mov]</th>
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</tr>
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<tr>
<td>[e-puck_mov]</td>
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</table>
Results on the e-puck
Results on the e-puck (2)

Figure 12 – short-time Fourier transform (Frequency of the signal and the energy measured)
Results on the e-puck (3)

The filter attenuates efficiently, even with great amplitude in low frequencies (simulated with a cpp program which create e-puck-like conditions).
Results on the e-puck (4)

E-puck with vibrations

E-puck without vibrations
Discussion on Webots

E-puck reacts properly (10 times over 10) when

• placed on the vibrating e-puck
• placed on the moving and vibrating e-puck
• gravity is defined at the beginning of the experimentation

E-puck doesn’t react (0 times over 10) when

• gravity changes during the experimentation (in direction and amplitude)
Discussion on Webots (2)

To improve the actual process:

- Initialize the gravity (direction and amplitude) at the beginning of the experimentation and update it when some settings change (go on a inclined ramp, change gravity, free fall)

- Filter the frequency of the above e-puck vibrations
Discussion on the e-puck

E-puck reacts properly (10 times over 10) when

• placed on the iPhone, on the box
• randomly moved with the hand
• hit with the hand on the table

E-puck reacts partially (~5 times over 10) when

• placed next to the iPhone, on the box

E-puck doesn’t react (0 times over 10) when

• skidded on the table surface
Discussion on the e-puck (2)

To improve the actual process:

• analyze data from slicing, and try to discriminate it when the e-puck is detecting an earthquake.

• adopt a smaller minimum threshold to detect small amplitude vibration of the good frequency (in case of e-puck placed next to the iPhone).
Video 1 : On the iPhone
Video 2 : Next to the iPhone
Video 3: When the e-puck is falling
Video 4: With a punch on the table
Video 5 : Skidding on the table
Limitations

• Range of the accelerometer
• Memory available and limited number of operations of the e-puck robot
• Harmonic frequencies
• Delay of response

What we did is to recognize and discriminate a known and precise vibration frequency (iPhone). But it would more difficult to detect an earthquake vibration considering its large frequency domain and amplitude.
Conclusion

• We are not able at this point of the project to make the difference between the S-wave and the P-wave

• The implementation on the e-puck is working as it discriminates the frequencies different that the frequency of the iPhone
Conclusion (2)

• Real implementation: for a real implementation of an earthquake detection, some problems can be faced:
  – The range of frequency of an earthquake is large
  – The range of amplitude is large too
  – Conclusion: difficult to detect only the earthquakes

Source: http://geophysics.eas.gatech.edu/