Towards a Wearable Device for Controlling a Smartphone with Eye Winks

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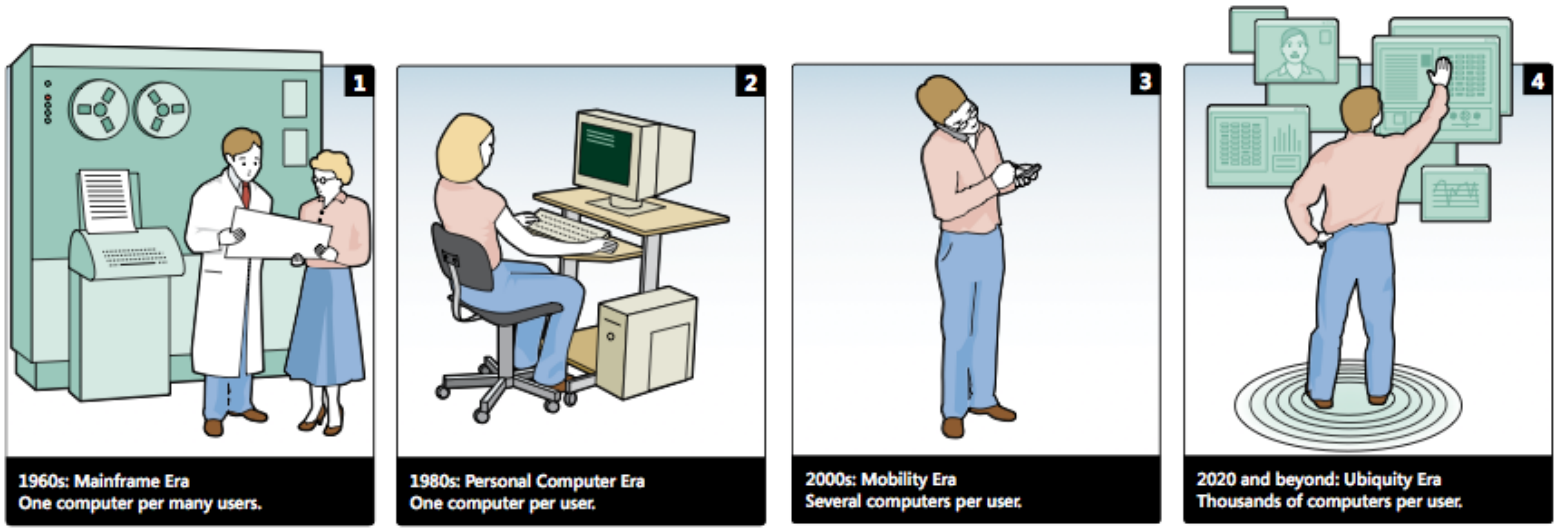
Outline

- Human-Computer Interaction
- EyeWink Architecture
- EOG Analysis
- Tests Conducted
- Results
- Conclusions and Future Work

Human-Computer Interaction

- Use technology to develop novel ways to interact with devices
- Applied to computers, home entertainment and smartphones



Interfaces for Smartphones

Voice-based

- E.g., Google Now, Apple Siri
- Require quiet environment
- Privacy issues

Eye-based

- E.g., Tobii EyeX, EyeTribe, apps
- Devices mainly for games
- Based on eye tracking
- Require smartphone in front of the user

EyeWink

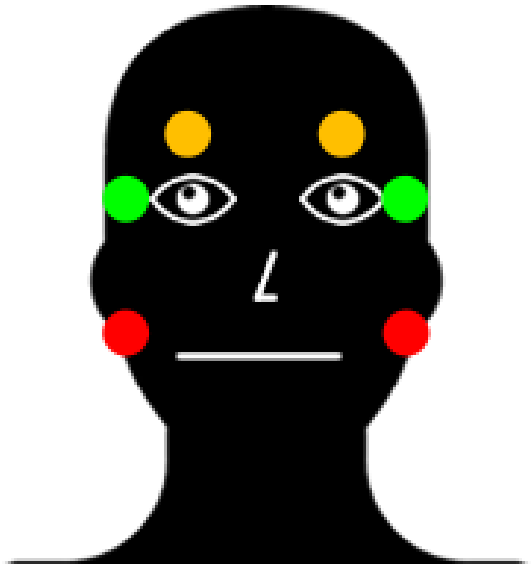
Idea

Use voluntary eye winks to command the smartphone

- Record muscular potentials
- Detect winks and filter out blinks
- Convert the winks into commands
- Stream the commands to the smartphone

Data Acquisition

- 2 active electrodes on the forehead or distally
- 2 extra reference electrodes (mastoids)
- Sampling rate: 250 Hz
- Data accumulated in epochs (100 samples)



Data Preprocessing

Main aim: artefact rejection

- Common average subtracted from each channel (CAR)

$$CAR(x_i(t)) = x_i(t) - \sum_{i=1}^{m} \frac{x_i(t)}{m}$$

  where $m = 2$ (number of electrodes)

- Band-pass filter

Limited preprocessing $\rightarrow$ compatible with real-time systems

Wink Detector

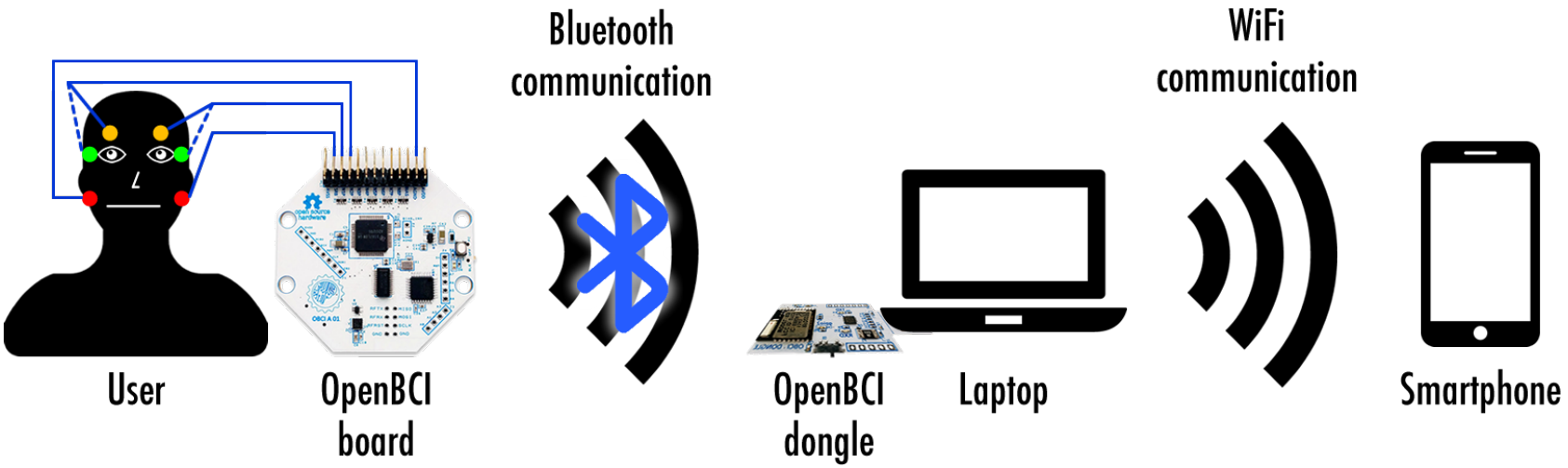
$A_l = \texttt{max}(\text{left epoch});$
$A_r = \texttt{max}(\text{right epoch});$
$D = A_l - A_r;$
$M = \texttt{min}(A_l, A_r);$
if $A_l > T_1$ *and* $(D - M) > T_2$ **then**
  Result: Left eye wink
else
  if $A_r > T_1$ *and* $(D - M) < -T_2$ **then**
    Result: Right eye wink
  else
    Result: No action
  end
end

Tuning

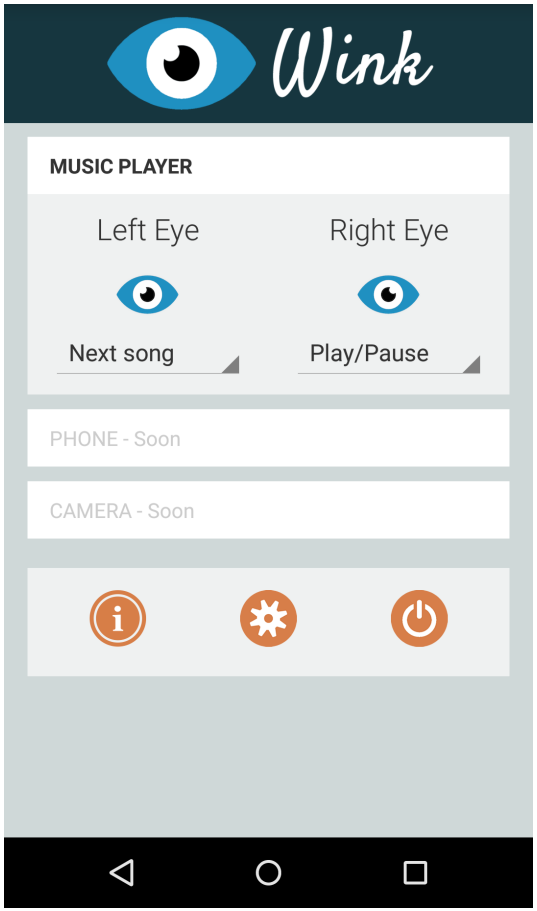
- The system is tuned manually by choosing the values of T_1 and T_2
- The user winks 4-5 times with each eye
- Thresholds adapted for different postures
  - sitting
  - standing
  - walking

Communication

Main aim: send the command (left/right wink/ no action)

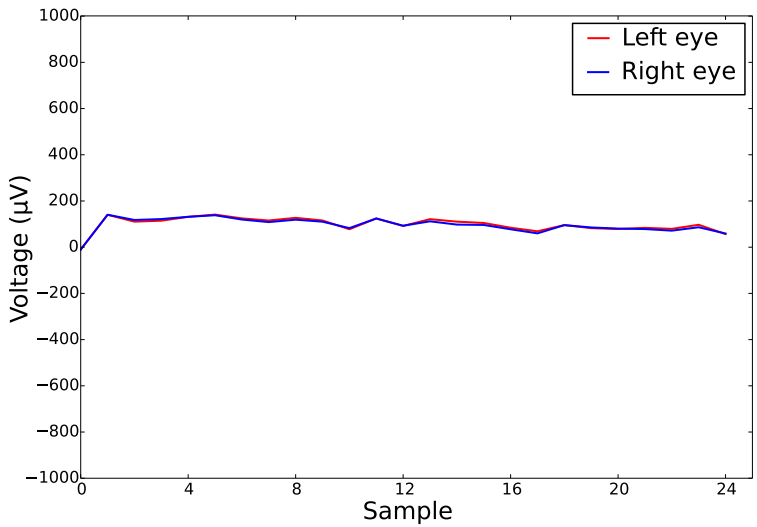


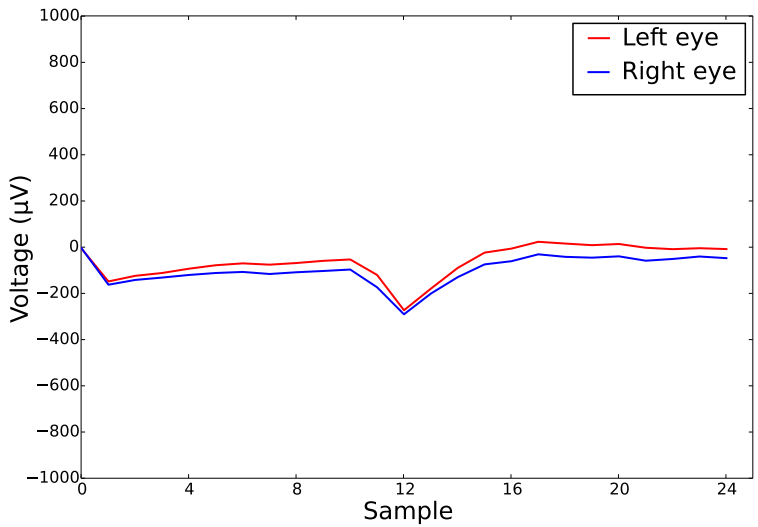
Smartphone App

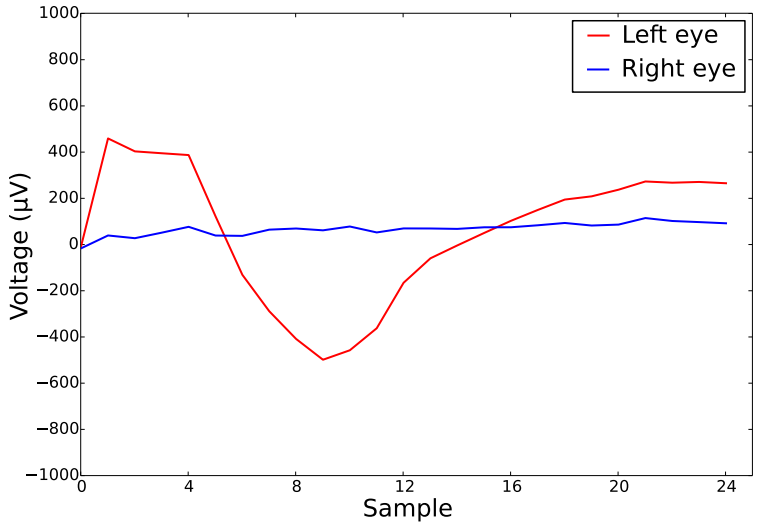


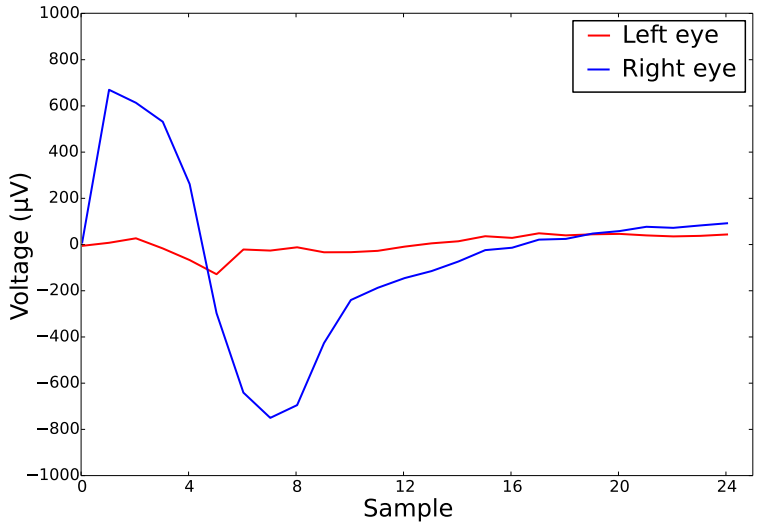
- Manages the connection with the computer
- Allows to associate an action to each eye wink
- Supports the music player
  - Play/Pause
  - Next song
  - Previous song
  - Volume up
  - Volume down

EOG Analysis









Tests

Device tested on 2 users:

- *cue-based* experiment: after tuning, participants performed 20 trials of each type (left wink, right wink, blink and no action)
- *free-mode* experiment: the user freely move/sit in a public park

Accuracy was measured by using the F_1 score

$$F_1 = \frac{2 \cdot TP}{2 \cdot TP + FN + FP}$$

Results

Cue-based

Tests repeated with different postures and position of the electrodes.

Configuration	**Participant A**		**Participant B**	
	Forehead	Distal	Forehead	Distal
Sitting	0.90	0.91	0.85	0.84
Standing	0.83	0.85	0.79	0.78
Walking	0.80	0.83	0.75	0.73

Free-mode

F_1 score of 0.85 after 2-hour experiment.

Conclusions

- Prototype to control a device with eye winks
- Simple algorithm for wink detection and blink filtering
- App to configure the smartphone

Future work

- Test dry electrodes
- Make the device wearable
- Stream the data directly from the board to the smartphone
- Add support of more applications in the EyeWink app

Questions?

Thank you for listening.