



# Phantom Limb Pain Project

Create a smart Interface

# Phantom Limb Pain Project

⇒ Reduce pain

- Create a realistic and user friendly system
- Moderate cost
- Adaptable to multiple users
- Self adaptable to a given user

3 months to :

1. Determine the usefull parameters
2. Choose the necessary hardware
3. Create a prototype  
and make it easily reusable





# An appropriate model

**Processing data to create a virtual limb**

**Make the system adaptable**



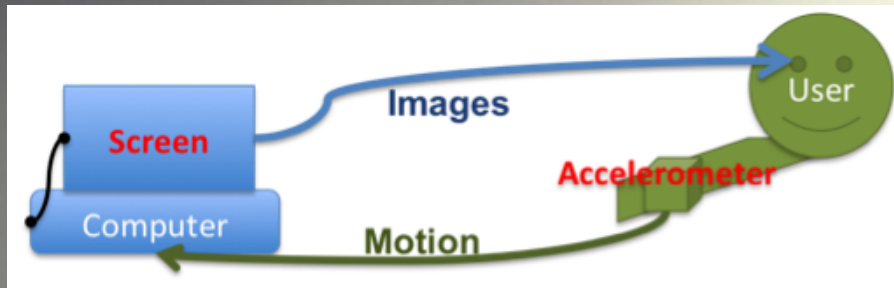


# An appropriate model

**Processing data to create a virtual limb**

**Make the system adaptable**

## Context



➤ Impossible to use all sensory informations to correct or modify the motion path

- Determine the moves of the user's limb from the moves of an other part of his body
  - stump
  - symmetrical limb
  - eyes
- Use the accelerometer and get the maximum of workable data

# Context

- 2 types of motion :
- Motion with user's feedback
  - Motion without user's feedback

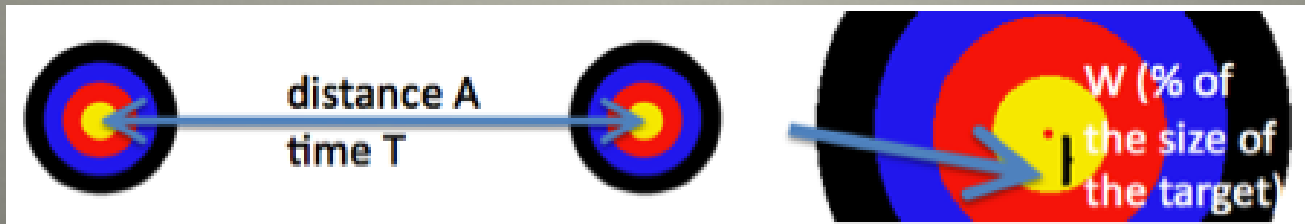
Task	Processing time of visual	Work
Alternate movements	500ms	[Woodworth 1999]
Target tracking movements	300~350ms	
Discrete movements of target attainment	190~260ms	[Keele <i>et al.</i> 1968]



# Empirical knowledge

Woodworth (1899) and by Fitts (1954)

$$T = a + b.I_d = a + b.\log_2\left(\frac{2.A}{W}\right)$$



## Empirical knowledge

MacKenzie (1992)

$$T = a + b \cdot \log_2 \left( \frac{A}{W} + c \right)$$

$c=1/2$  [Welford 1968] or  $c=1$  [MacKenzie 1992]

Schmidt

$$W_e = a + b \frac{A}{T}$$

## Empirical knowledge

The principle of isochronie established by Freeman (1914)

$$V = kA^\alpha$$

Meyer *et al.*

$$T = a + b.n \left( \frac{A}{W} \right)^{1/n}$$





# An appropriate model

**Processing data to create a virtual limb**

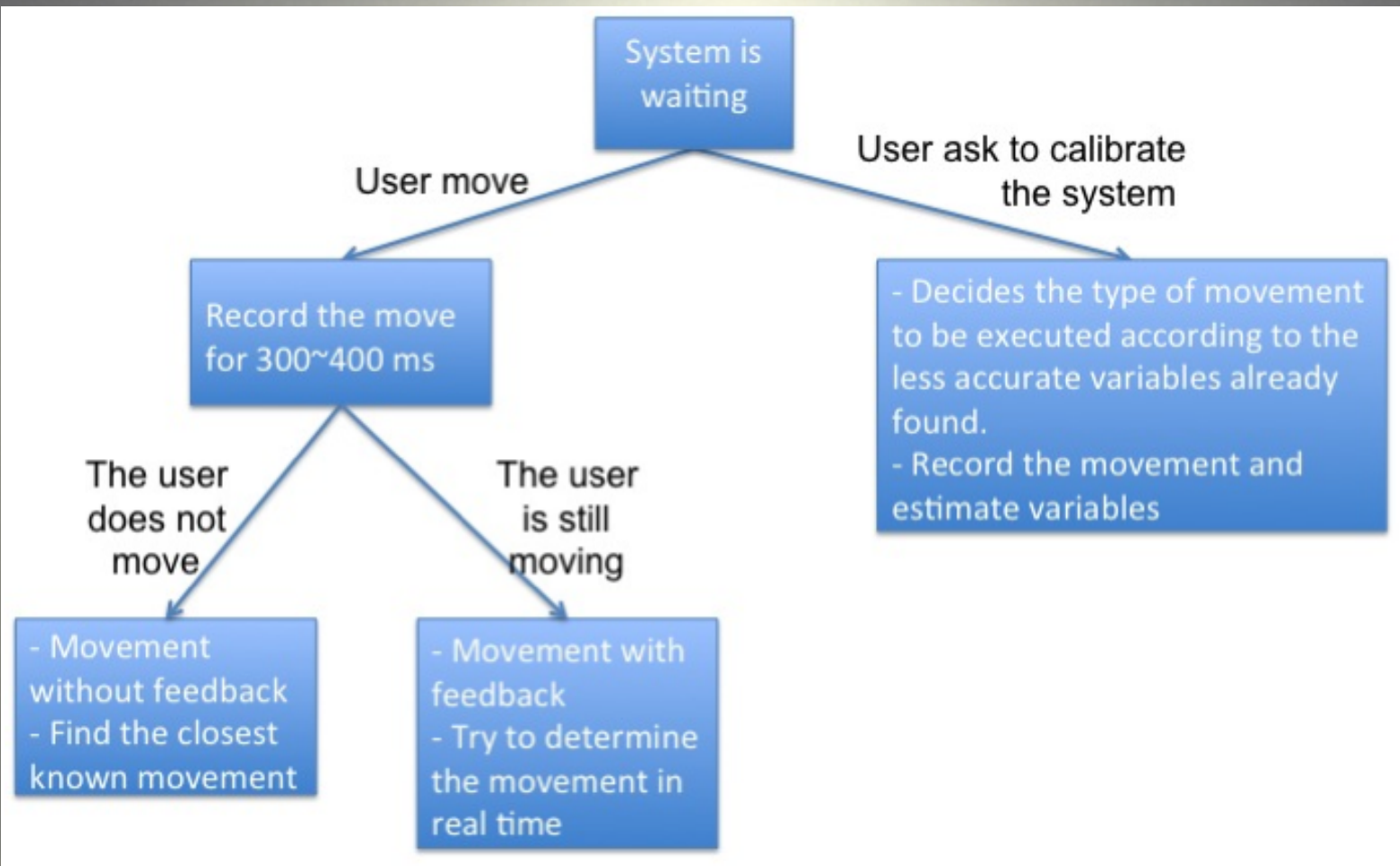
**Make the system adaptable**

## For a specific user

2 types of motion :

- The user is asked to perform a specified move in order to calibrate the system
- The user is actually using the system

# For a specific user





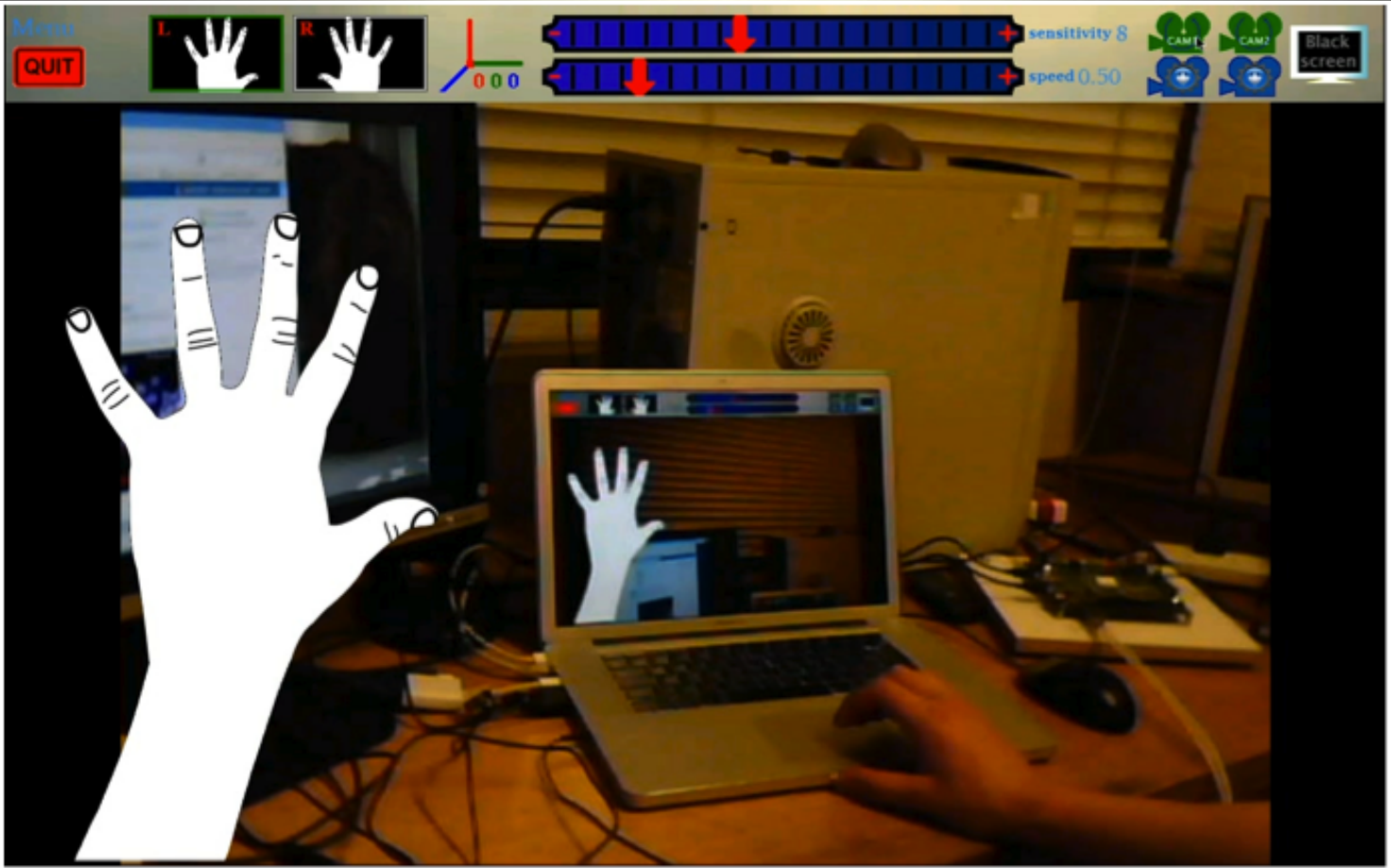
## To different users and environments

The system must be able to adapt whatever the reference user

- Depending on the pathology
  - Which limb to model
- Depending on the environment
  - Take a picture of the background

An appropriate model > Make the system adaptable

# Overview





# The hardware

**Minimum hardware: I2C on VGA**

**Only FPGA : Handel-C**

**FPGA and Interface on Windows**



A desk lamp with a black adjustable arm and a silver-colored lamp head is positioned in the upper left corner. The lamp is turned on, casting a warm, yellowish glow onto the slide. The lamp head has a series of small, rectangular light sources. The slide itself is a light gray color with a subtle gradient.

# The hardware

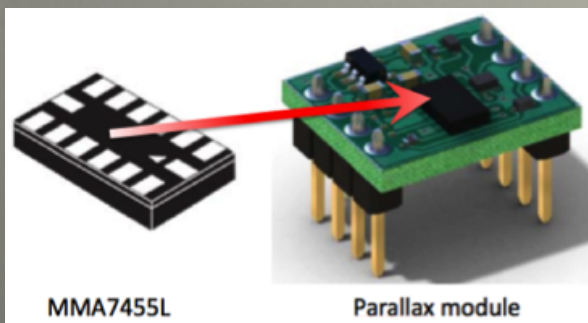
**Minimum hardware: I2C on VGA**

**Only FPGA : Handel-C**

**FPGA and Interface on Windows**

## Only one accelerometer

- Some human movement can be quick ~50ms
- Measure position and speed at high frequency



Relevant information about the accelerometer	
Name	MMA7455L
Axes	3 axes: X, Y, Z
Communication protocol	I2C or SPI
SPI frequency	8MHz
Selectable range	$\pm 2g$ ; $\pm 4g$ ; $\pm 8g$
Voltage	2.4V - 3.6V

## 25¢ I2C Adapter Project

- Plug-and-play system
- Only needs a 0,5£ connector
- Use the controls lines present on many graphics card to interface I2C device


















VGA wire	I2C wire
PIN 5 : Ground	Ground
<b>PIN 9 : +5V</b>	VIN
<b>PIN 12 : Data</b>	SDA
<b>PIN 15 : Clock</b>	SCL





# Limitations

- Compatibility range is limited
- Likely warranty-voiding operation
- I was unable to get data from MMA7455

Compatibility			
			
			
			



# The hardware

**Minimum hardware: I2C on VGA**

**Only FPGA : Handel-C**

**FPGA and Interface on Windows**

## Celoxica RC10

- + Start from the work already done
- Celoxica doesn't support this board any more
- Need to create an elaborate graphic interface







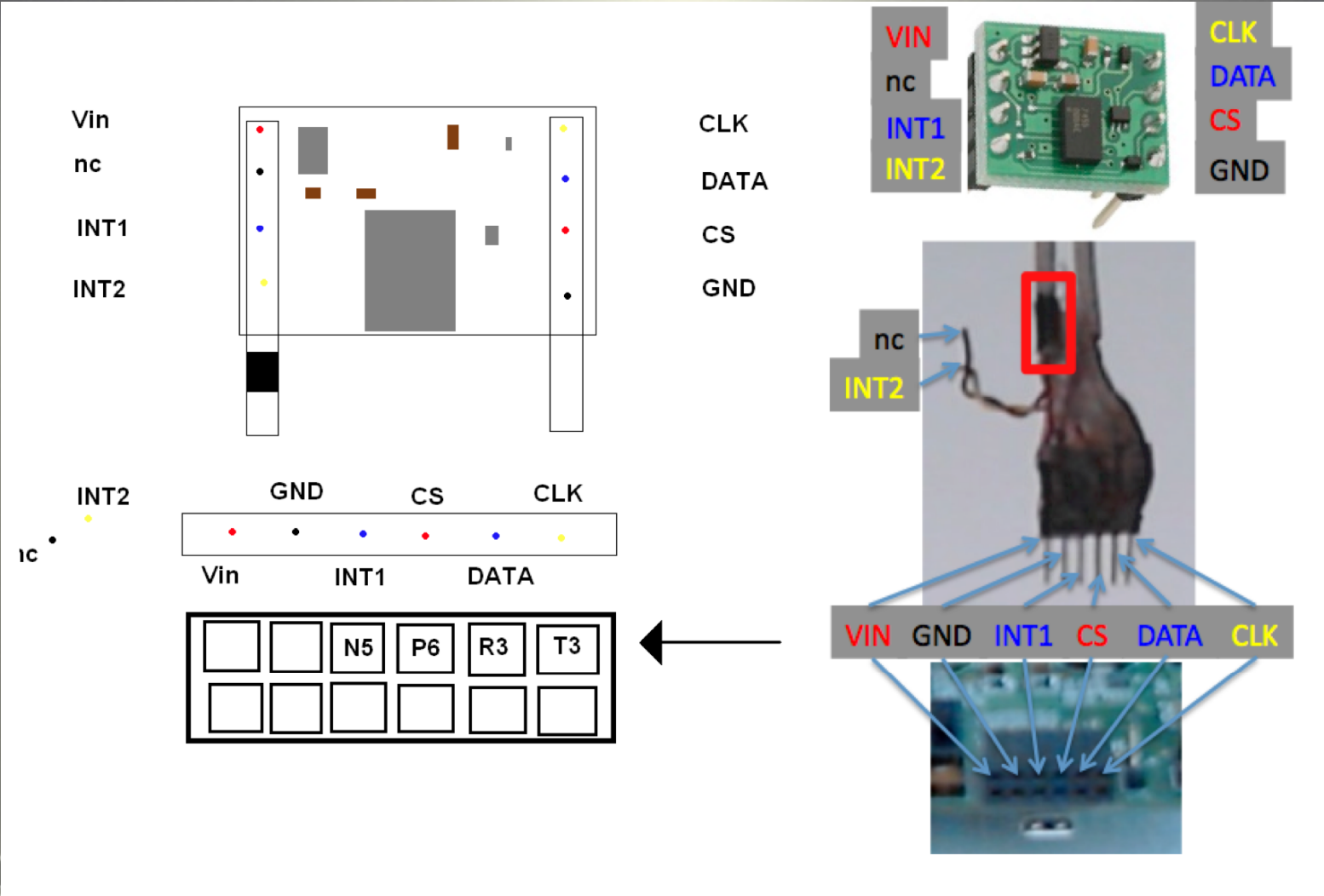
# The hardware

**Minimum hardware: I2C on VGA**

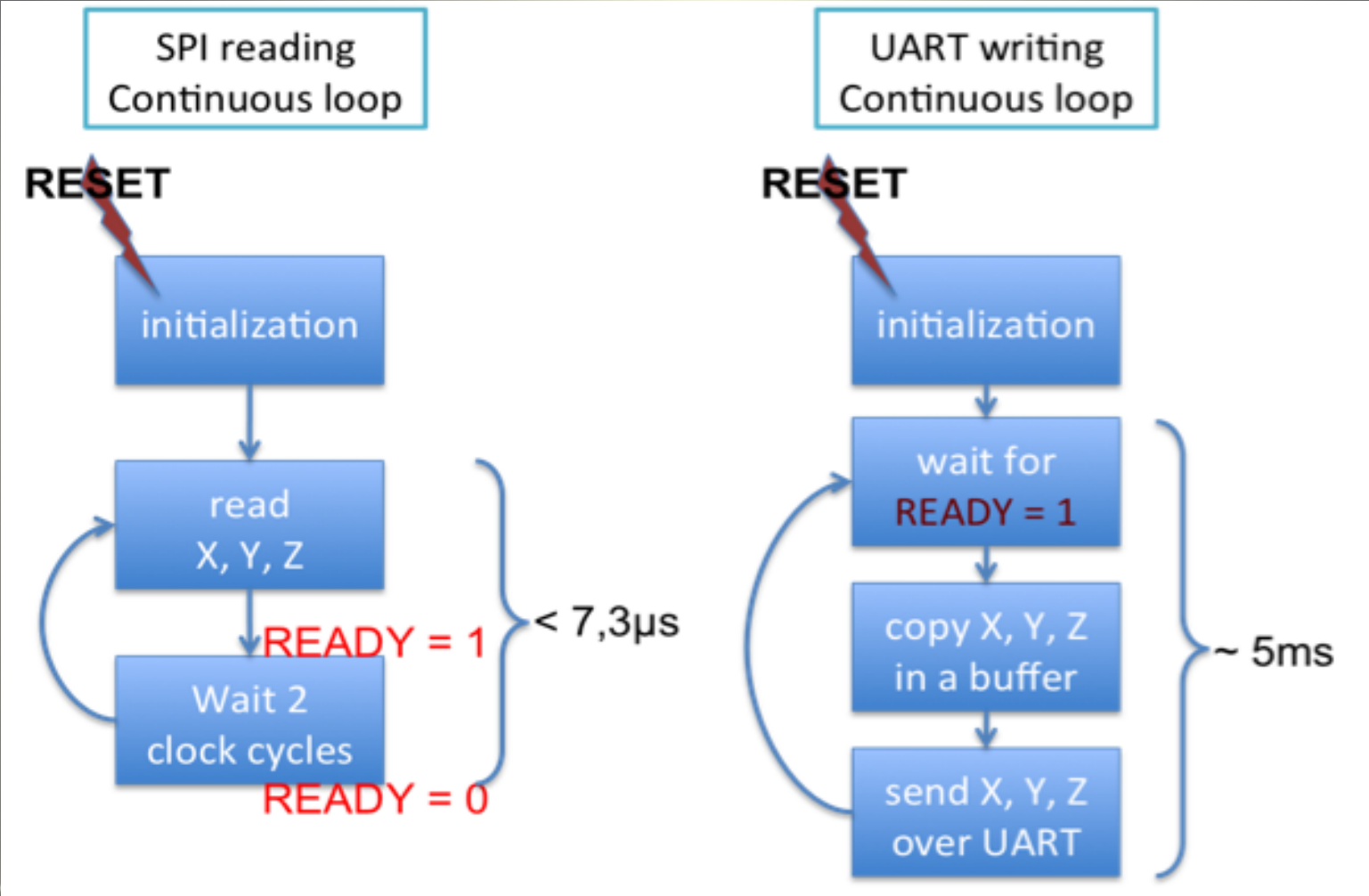
**Only FPGA : Handel-C**

**FPGA and Interface on Windows**

# Acquire data : SPI is faster than I2C



# Acquire data and sending then to the computer



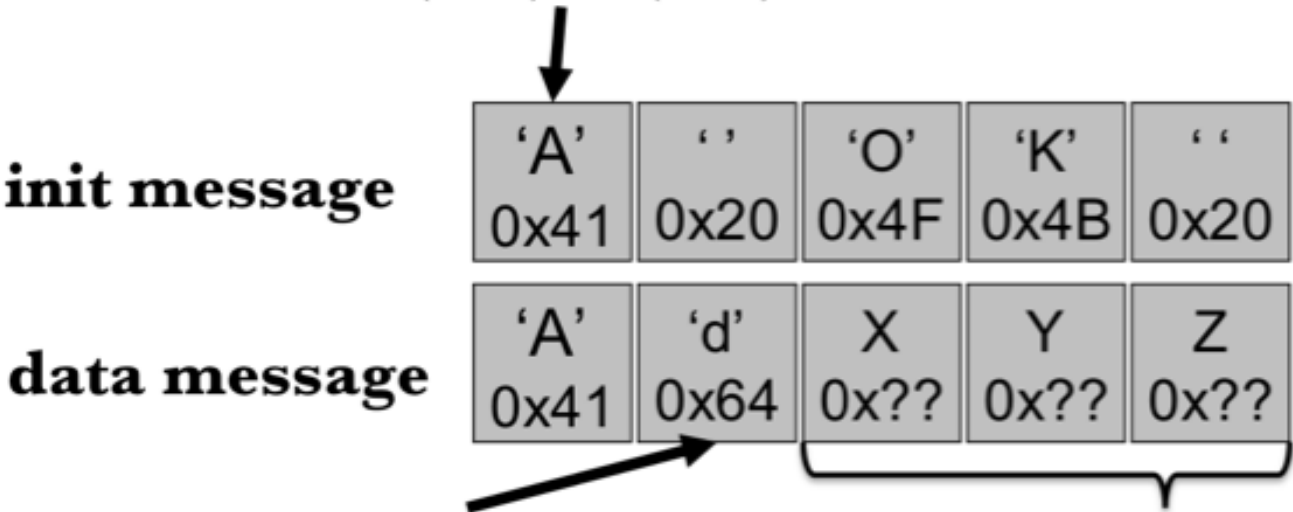


## Sending data to the computer

- Chip XR21V1410 embedded on the Atlys is an USB-UART
- 9600 baud, 8 bits data, 1 stop bit, no parity
- Send 5 bytes during each transmission

# Sending data to the computer

The transmission begins with a known character so appears to be correct. The message is about the sensor A. If several sensors, it could be 'B' (0x42), 'C' (0x43), etc

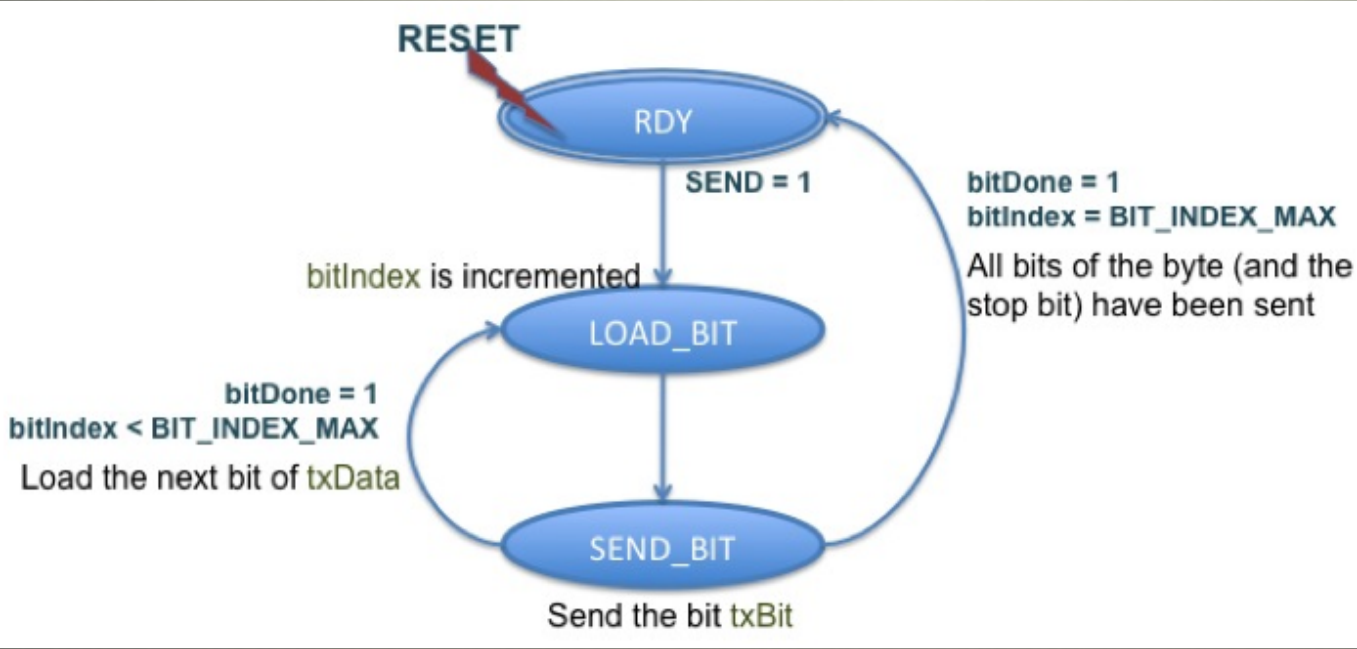


If 'd' (0x64), the message contains data.  
If ' ' (0x20), the message contains information  
If other, the message is corrupted or is not from the correct source.

Content of the message

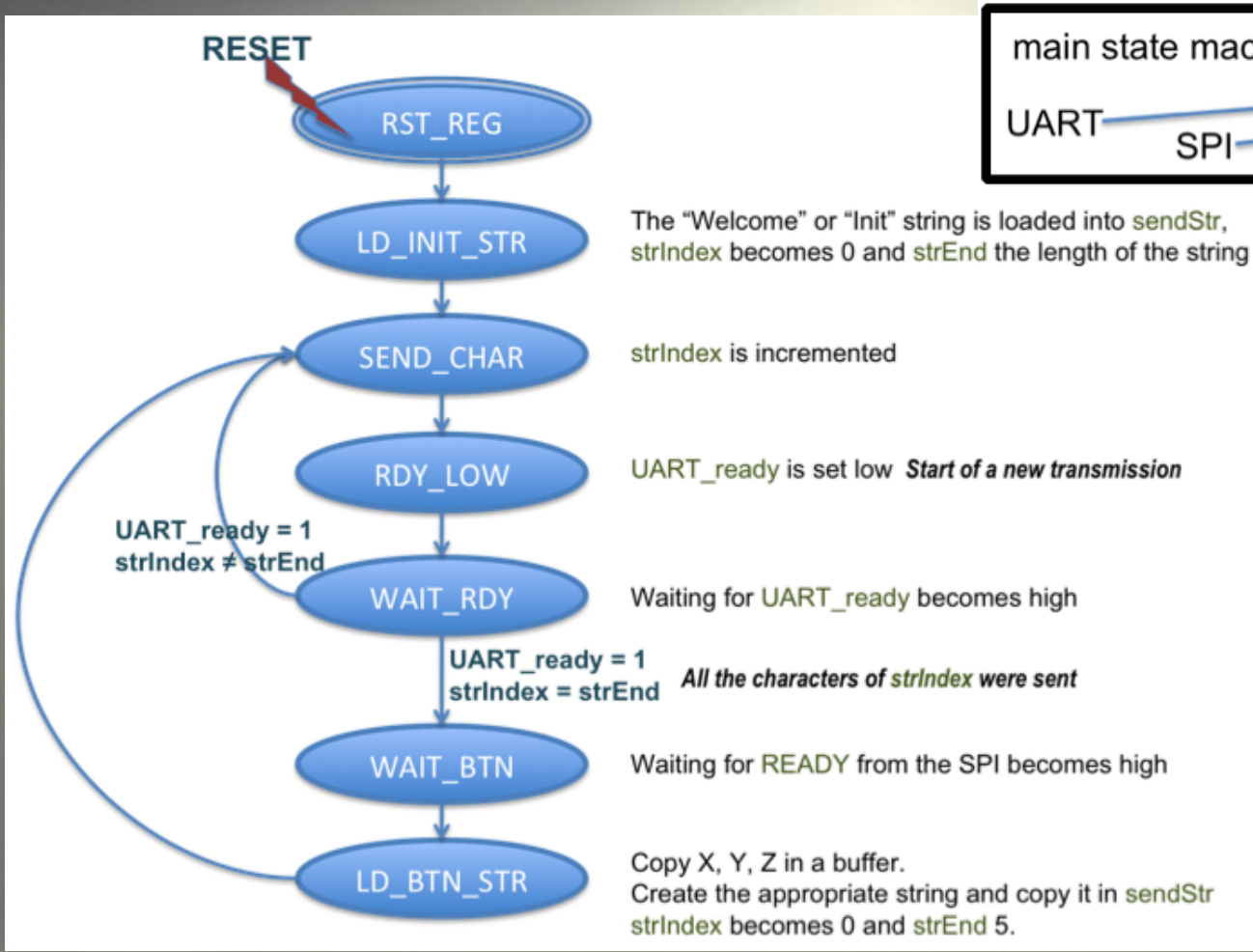
# Sending data to the computer

UART is operated in “UART\_TX\_CTRL”



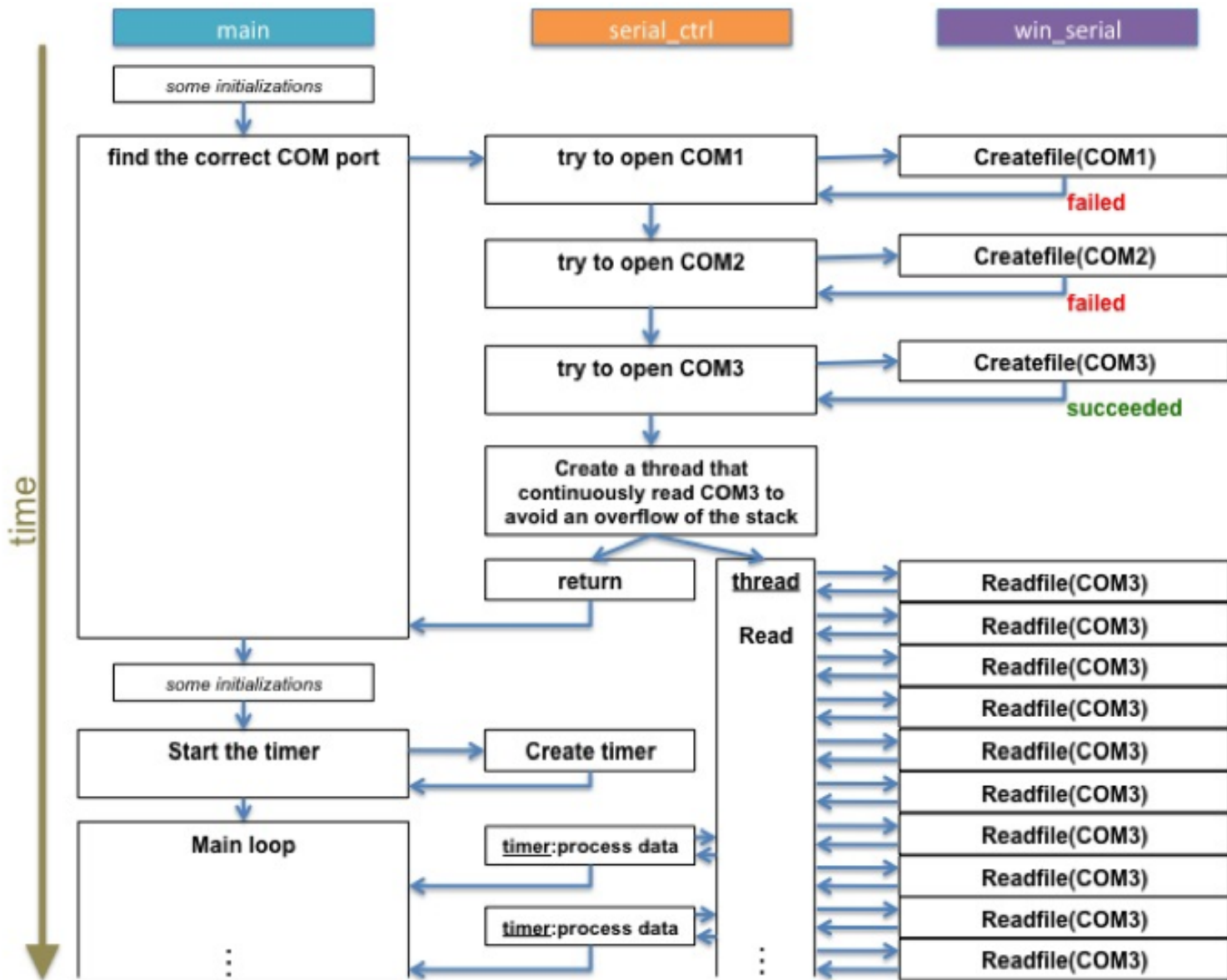


# Sending data to the computer



Main state machine  
"GPIO\_demo"

## The hardware > FPGA and Interface on Windows

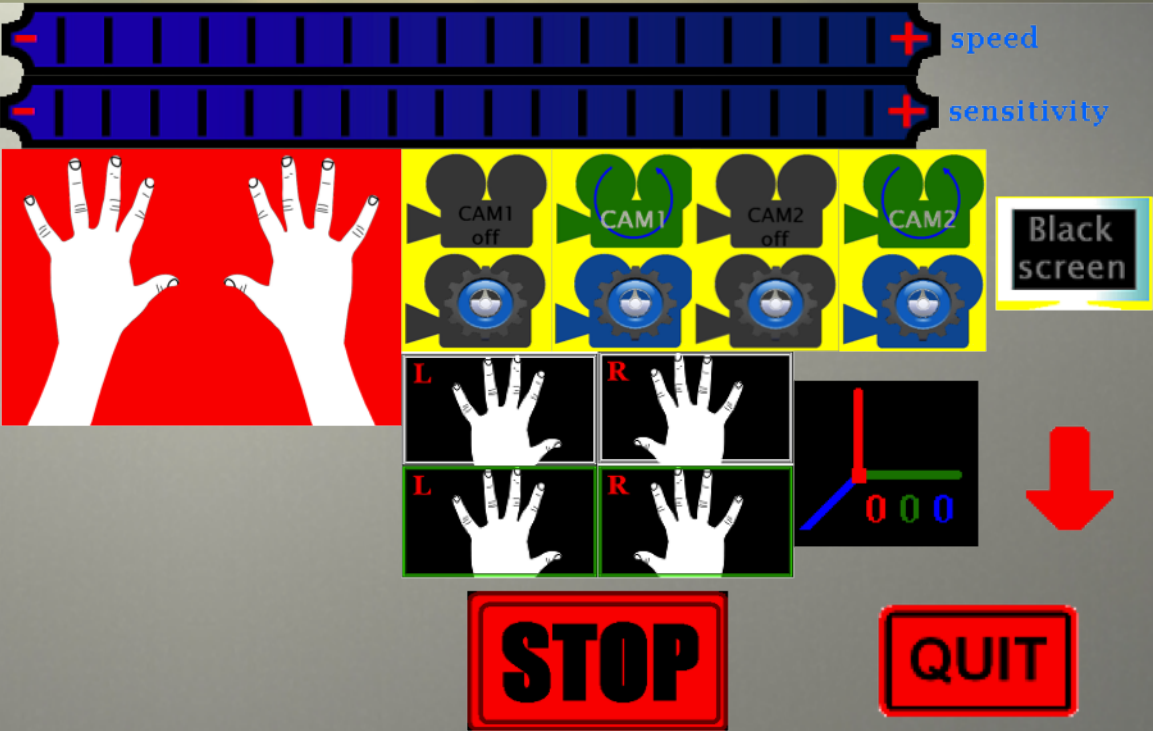
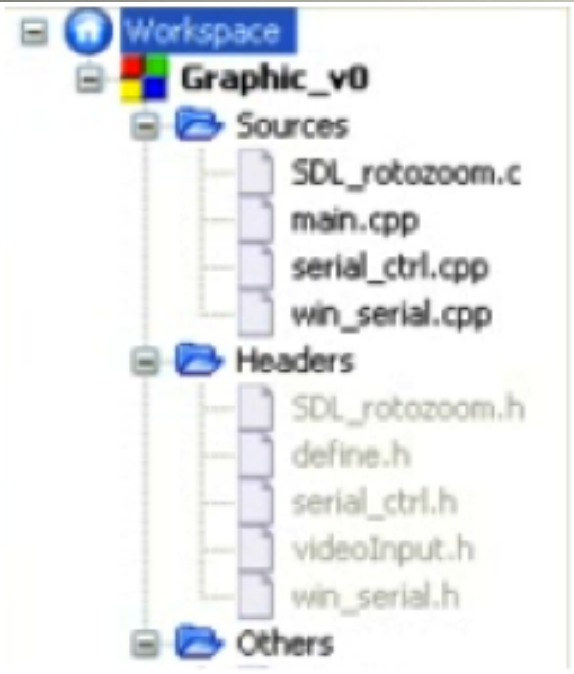


## The graphic interface

- Simple and user friendly interface
- Development environment : MinGW
- IDE : Code::Blocks
  - Graphics library : SDL
    - SDL\_ttf
    - SDL\_gfx
  - Capture from webcam : VideoInput



# The graphic interface



A detailed illustration of a classic desk lamp with a black adjustable arm and a silver-colored base. The lamp is positioned on the left side of the frame, casting a warm, yellowish glow onto a light gray background that resembles a presentation screen. The lamp's head is tilted downwards, focusing the light on the text area.

# Create a prototype

**Difficulties**

**Make it reusable**

**Improvements**

A desk lamp with a black adjustable arm and a silver-colored base is positioned on the left side of the frame. The lamp's head is tilted downwards, casting a warm, yellowish glow onto a light gray surface that serves as a background for the text. The lamp's arm features a coiled spring mechanism. The background has a subtle horizontal gradient and a thin white line near the top.

# Create a prototype

**Difficulties**

**Make it reusable**

**Improvements**



## Technical and managerial

- Use a single pin of the FPGA both as an input and a output
  - Use an *inout* I/O
  - Create a signal that determines the direction
- Manage my time
  - Set goals and achieve them as much as possible
  - Limit my objectives to not try developing something that I would not have time to finish



# Create a prototype

**Difficulties**

**Make it reusable**

**Improvements**

## How ?

- Comments in the code
- All constants in the define.h
- Useful information to retrieve my work in the Technical Manual
- Last versions and resources on [plp.antoinem.com](http://plp.antoinem.com)



A desk lamp with a black adjustable arm and a silver-colored base is positioned on the left side of the frame. The lamp's head is tilted downwards, casting a warm, yellowish glow onto the surface of the presentation slide. The slide itself is a light gray color with a subtle horizontal gradient. The background behind the slide is a dark, solid color.

# Create a prototype

**Difficulties**

**Make it reusable**

**Improvements**

## Possibilities of improvement

- Replace the FPGA by a simple micro-controller
- Add a different sensor like a gyroscope
- Make it entirely cross-platform
- Rely a lot more on the equations
  - Develop scenarios to help the user calibrate the system



# Conclusion

- Learn a lot in new fields like human movement
- Use my engineering knowledge
- Interdisciplinary work
- Many opportunities and many features to add
- Not yet testable but might be a step



A 3D rendered scene featuring a black adjustable desk lamp on the left, casting a bright, circular glow onto a large white rectangular surface that resembles a whiteboard. The text "Any question ?" is centered on this surface in a blue, sans-serif font. The background is a dark, textured grey. In the top right corner, there is a small, yellow, wireframe geometric shape.

**Any question ?**