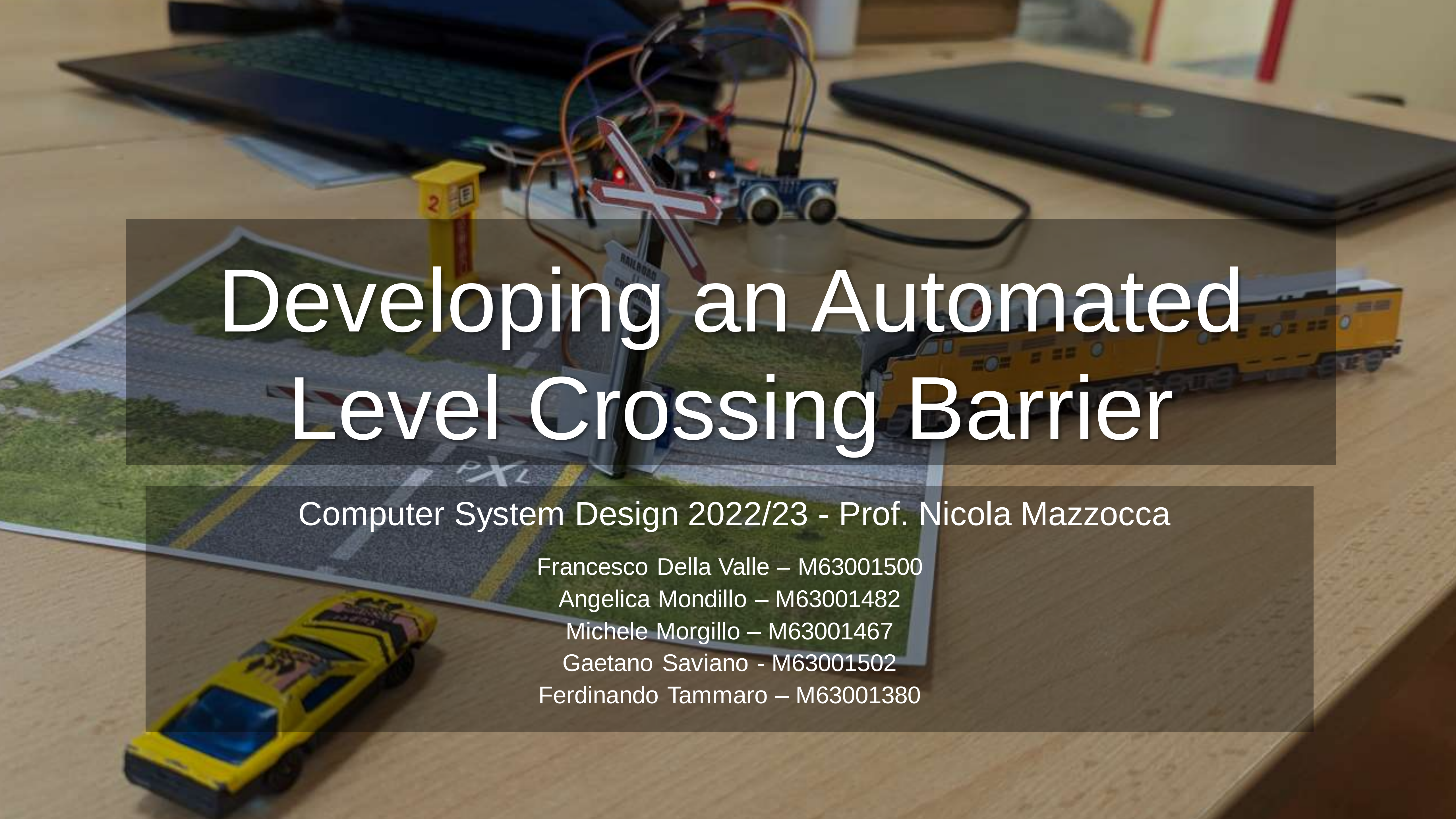

Developing an Automated Level Crossing Barrier

Computer System Design 2022/23 - Prof. Nicola Mazzocca

Francesco Della Valle – M63001500
Angelica Mondillo – M63001482
Michele Morgillo – M63001467
Gaetano Saviano - M63001502
Ferdinando Tammaro – M63001380

Project Scope

Objective: Design and implement a level crossing barrier system

Focus: Development of an automated system with ultrasound sensor technology

Inclusions: Ultrasound sensor, barrier mechanism, control system, manual override feature, reset functionality

Technology

- Board : STM32F401RE Nucleo-64
- Ultrasound Sensor: HC-SR04
- Servomotor: SG90
- LED R 3mm
- Push Button 6x6 mm
- Mini-USB cave
- Resistor 0.25W-330Ω

Project Phases

- Case Studying
- Design phase
- Implementation phase
- Testing phase

Case Study

The objective of this case study is to address the safety and efficiency issues at a busy level crossing by implementing an automated barrier system.

The existing level crossing faced frequent safety incidents and traffic congestion. Manual operation of the barrier resulted in human errors and delays, posing risks to pedestrians and vehicles. There was a need for an automated solution to improve safety and optimize traffic flow.

To resolve the above issues, we designed and implemented an automated level crossing system with a barrier. The system incorporated advanced control system and sensor technology, along with a robust barrier mechanism

Design Phase

The design process involved the following steps:

- **Sensor Integration**: We carefully connected the ultrasound sensor to the control board, ensuring proper communication and data transfer. The sensor was strategically positioned near the level crossing to accurately detect approaching trains.
- **Distance Measurement**: The sensor continuously measured the distance between the level crossing and the train using ultrasound waves. This data was fed to the control system for further analysis.
- **Automated Barrier Lowering**: Based on the measured distance, the control system determined if the train was within a predefined range. If the distance was below the threshold, the system automatically triggered the barrier lowering mechanism to secure the crossing.
- **Manual Override**: To account for sensor malfunctions, we implemented a manual override feature. A designated official could manually lower the barrier by activating an override button, ensuring safety in the absence of functioning sensor data.
- **Reset Functionality**: In order to restore the system to its default automatic operation mode, a reset button was incorporated. Pressing this button would reset the system, reactivating the sensor and resuming the automatic train detection and barrier operation.

Implementation Phase

In the implementation phase, we performed the following tasks:

- **Enable TIM1:** We enabled the TIM1 timer in order to use the HC-SR04 sensor.
- **Enable TIM3**: We enabled the TIM3 to generate the PWM for the motion of the SG-90 servomotor.
- **Enable PC13 for PushButton**: The PC13 pin was configured and enabled as an input for the PushButton functionality.
- **Configure PA11 as GPIO_Output**: The PA11 pin was set up as a GPIO output to control the barrier lowering mechanism.
- **Configure PB12 as GPIO_Input**: The PB12 pin was configured as a GPIO input to receive sensor data or any other relevant input.
- **Enable PA10 for Override Button**: The PA10 pin was enabled to serve as an input for the Override Button. This button would trigger an interrupt on the EXTI10 line when pressed.
- **Configure PB9 as GPIO_Output for the LED**: The PB9 pin was configured as a GPIO output to control the LED, providing visual indications or status updates.

Implementation Phase

- **For the implementation** of the sensor mechanism, we utilized the polling technique. In the event of a sensor failure, pressing a button on the breadboard would trigger an override.
- **The distance measured by the sensor was compared to a predefined threshold value within the polling loop**. When the distance drops below said threshold, it indicates the presence of a train lowering the bar.
- **We incorporated a manual override functionality in case of a sensor malfunction. Pressing the button on the BreadBoard generates an interrupt.** Through this interrupt, a callback is executed that overrides the sensor and switches to manual controls.

Implementation Phase

- **To restore the system** to its standard operation, which is the movement of the barrier triggered by the sensor, the reset button on the board is pressed. When pressed, an interrupt is generated, and a callback gets executed. This callback deactivates the manual override mode and restores the system to its default automatic operation.
- **The barrier mechanism will once again respond to the signals from the sensor**, automatically raising or lowering the barrier based on the train's presence.

Testing Phase

During the testing phase, we focused **on configuring the sensor,** adjusting delays, and determining the minimum distance required for optimal problem resolution.

In the following slides, we will demonstrate the simulation of the system's operation:

- Correct Functioning
- Override Button
- System Reset

Future Considerations:

Stay updated with the latest advancements in sensor technology for improved train detection accuracy

Explore the possibility of integrating additional sensors or technologies to further enhance safety and efficiency

Implementation of Intelligent Systems with Computer Vision for greater safety