

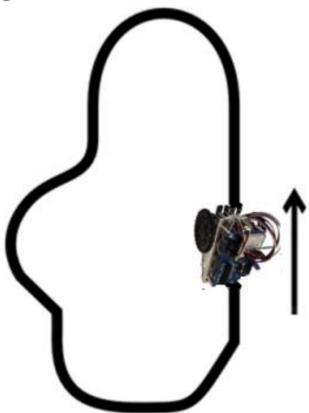
## “Demo: On-line Supervisor for the Line Follower Robot”

Maurizio Palmieri, Carlo Vallati, Giuseppe Anastasi, Cinzia Bernardeschi  
 Department of Information Engineering, University of Pisa, Italy  
 { name.surname@ing.unipi.it }



### Line Follower Robot digital-twin

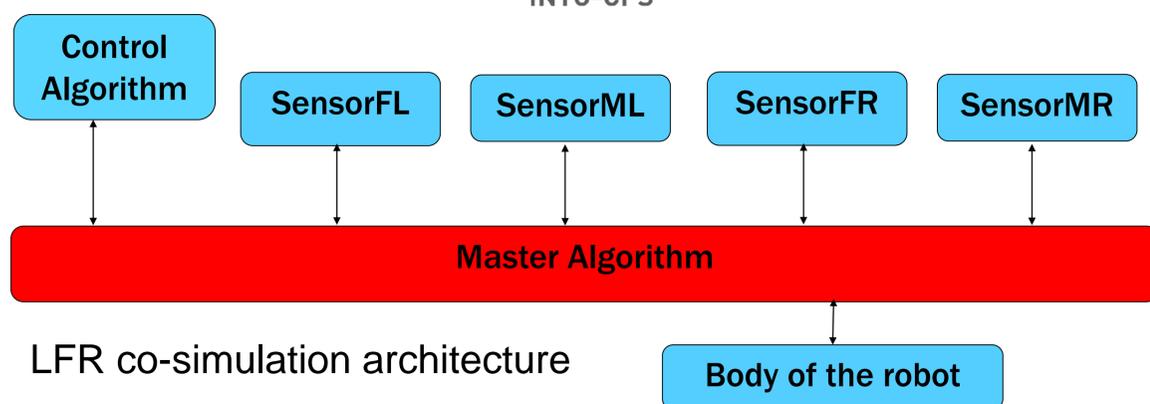
Line Follower Robot (LFR): the line contrasts from the background and the robot uses 4 sensors to detect light and dark areas.



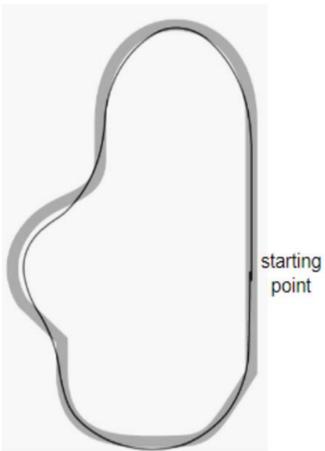
Equipment:

- 4 light sensors (FarLeft - FL, MediumLeft -ML, MediumRight MR, FarRight FR)
- 2 wheels (with motors)
- 1 Arduino board
- 1 Wifi-Shield
- 5 Batteries

FMI standard for co-simulation  
 INTO-CPS association



### What-if analysis



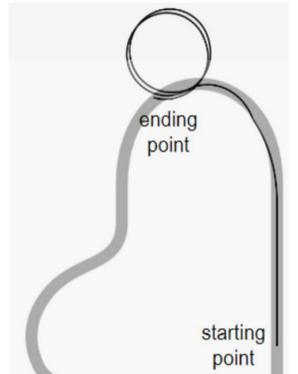
The sensor model provided by INTO-CPS integrates a mechanism for fault injection that can be triggered during the co-simulation by setting two specific parameters of the sensor FMU, namely `fail_time` and `stuck_value`



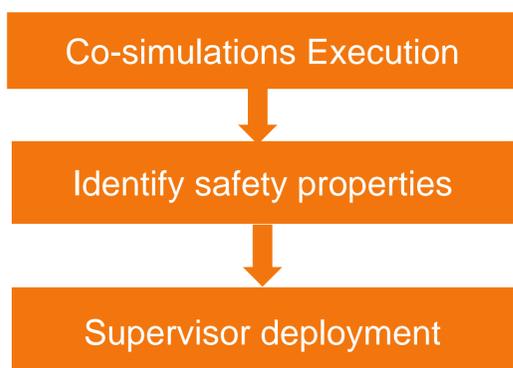
Injection of a stuck-at fault that forces value of `stuck_value` as output of the FMU after `fail_time` seconds since the beginning of the co-simulation, until the end of the co-simulation

The robot, after the first curve, begins to turn right endlessly, as one of the right sensors always senses the line (the value 100 is below the threshold so it is perceived as dark ground).

Stuck-at 100 of SensorRightFar from co-simulation time = 3s



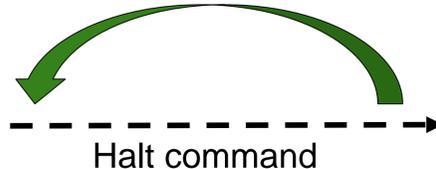
### Remote Supervisor Checking Safety Rules



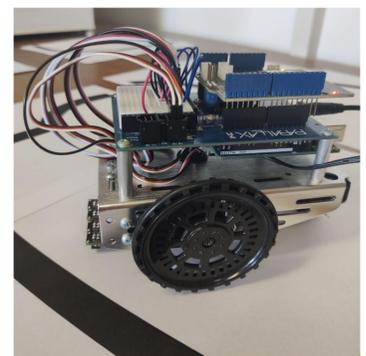
Remote Supervisor



Periodic stream of data



Check every message received. If any safety property is violated, send the Halt command



LFR periodically send the sensor data. If a message is received execute the command within

Arduino Wifi-Shield connected to the Arduino Uno of the LFR enables the wireless communication with the remote supervisor (following the standard IEEE 802.11 b/g)

### Conclusions

When cyber-physical systems execute safety-critical tasks, monitoring of their behavior is of main concern. This demo shows how data collected off-line by a digital-twin can be used to design an on-line remote supervisor of a Line Follower Robot. The Controller of the robot on the Arduino board has been easily extended to receive commands from the supervisor; the robot is stopped in case of unexpected behavior, thus avoiding unsafe situations.