System Requirements Specification

for

Overtake and Collision Avoidance with Thymio

Version 0.1

Prepared by Lorenzo Bartolini, Marco Agatensi

University of Florence

03/04/2025

(a modified version of IEEE Software Requirements Specification Template, K.E. Wiegers, 1999)

Table of Contents

1. Introduction 1

1.1 Purpose 1

1.2 Document Conventions 1

1.3 Intended Audience and Reading Suggestions 1

1.4 Product Scope 1

1.5 References 1

2. Overall Description 2

2.1 Product Perspective 2

2.2 Product Functions 2

2.3 User Classes and Characteristics 2

2.4 Operating Environment 2

2.5 Design and Implementation Constraints 2

2.6 Assumptions of Use 3

3. System Use Cases 3

3.1 Reach the end of the road 3

3.2 Come back to the start 4

4. System requirements definition 5

4.1 Viewpoint 1 or System Feature 1 5

4.2 System Feature 2 (and so on) 5

5. Traceability matrix 6

6. Test Cases/Test Plan 6

6.1 Test Cases/Test Plan Traceability Matrix 6

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Date** | **Reason For Changes** | **Version** |
|  |  |  |  |
|  |  |  |  |

# Introduction

## Purpose

The purpose is to design an overtake and collision avoidance system composed of two Thymios in a well specified environment.

## Document Conventions

None

## Intended Audience and Reading Suggestions

Intendend audience is developers, project managers, testers and documentation writers.

## Product Scope

The product scope is to design two Thymios that are able to reach their destination without colliding and applying a well specified collision avoidance algorithm.

## References

None

# Overall Description

## Product Perspective

The project in object is part of a University project.

## Product Functions

* Guide two Thymios to destination
* Perform overtakes
* Avoid collisions

## User Classes and Characteristics

None

## Operating Environment

The environment will be a narrow and long road with two Thymios.

## Design and Implementation Constraints

Constraints involve the hardware of Thymios and the related limitations, such as speed and sensors accuracy. Another constraint is the language to code the two Thymios.

## Assumptions of Use

The main assumptions comes from the environment: no obstacles, walls in all directions, road in the middle. Also the role of the two Thymios is important, they are not interchangable.

# System Use Cases

# 

## Reach the end of the road

1. **Objective** – The two Thymios should be able to reach the end of the road, Thymio A needs to overtake Thymio B without crashing.
2. **Priority** – High
3. **Actors** – Two Thymios (A and B)
4. **Flow of Events** 
   1. **Basic Flow**
      1. Thymio A and B move forward
      2. Thymio A reaches B
      3. Thymio A performs the overtake returning on the road
      4. Thymio A and B move forward
   2. **Alternative Flow(s)**
      1. Thymio A and B move forward
      2. Thymio A reaches B
      3. Thymio A while performing the overtake is not able to return on the road in front of B
      4. Thymio A retries to perform the overtake
   3. **Exception Flow(s)**
      1. Thymio A and B move forward
      2. Thymio A reaches B
      3. Thymio A crashes on B while performing the overtake
5. **Includes** - None
6. **Preconditions** – Thymio A is behind Thymio B, Thymio A is faster than Thymio B
7. **Post conditions** – Thymio A reach the end of the road, Thymio B still needs to reach the end of the road
8. **Notes/Issues** - None

## Arrive at destination

1. **Objective** – The two Thymios should be able to arrive at destination without crashing when doing it
2. **Priority** – High
3. **Actors** – Two Thymios (A and B)
4. **Flow of Events** 
   1. **Basic Flow**
      1. Thymio A turns around while B moves forward to reach the end of the road
      2. Thymio A and B face eachother going in opposite directions
      3. They avoid the collision
      4. Thymio A and B continue on the road
      5. Thymio B reaches the end
      6. Thymio A and B arrive at destination
   2. **Alternative Flow(s)**
      1. Thymio A turns around while B moves forward to reach the end of the road
      2. Thymio A and B face eachother going in opposite directions
      3. While trying to avoid collision they get stuck
      4. Thymios get back to a stable condition and retry
      5. Thymio A and B continue on the road
      6. Thymio B reaches the end
      7. Thymio A and B arrive at destination
   3. **Exception Flow(s)**
      1. Thymio A turns around while B moves forward to reach the end of the road
      2. Thymio A and B face eachother going in opposite directions
      3. They collide in the attempt of avoiding the incident
5. **Includes** - None
6. **Preconditions** – Thymio A is at the end of the road, Thymio B still needs to reach the end of the road
7. **Post conditions** – Thymio A and B has arrived at destination
8. **Notes/Issues** – The destination of A is the starting position, the destination of B is the end of the road

# System requirements definition

## Architectural Viewpoint

**USER REQUIREMENTS**

USR1-M: Thymio A and B must be able to move forward;

USR2-M: Thymio A must be able to do an overtake;

USR3-M: Thymio A must be able to turn around;

USR4-M: Thymio A and B must be able to indentify the end of the road;

USR5-M: Thymios must be able to avoid collision with each other;

USR6-M: Thymios must be able to identify the other Thymio on the way;

USR7-M: Thymios must be able to follow the road;

USR8-M: Thymio A must be able to go faster than B;

USR9-M: At SoS start Thymios must be in the initial configuration;

**SYSTEM REQ**

**Environment Requirements**

SYS1-R: The Thymio should operate on a space of 1m x 3m;

SYS2-M: The surface must be flat and smooth;

SYS3-R: The Thymio should not operate in a too bright area;

SYS4-M: There must not be obstacles in the entire area;

SYS5-M: The area must contain a single road;

SYS6-R: The end of the road should be delimited;

**SoS structure and rules Requirements**

SYS7-M: The SoS must be composed of 2 Thymios;

SYS8-M: The SoS target must be that each Thymio reaches its final destination without crashing;

SYS9-M: At Sos starts, the Thymios must be positioned on the road facing the same direction;

SYS10-M: At Sos starts, the Thymio B must be in front of A;

SYS11-M: The execution must complete when Thymio A reaches the start of the road and B reaches the end of the road;

SYS12-M: The Thymios must know that the only other entity is the other Thymio;

SYS13-M: Thymio A must perform an overtake when it reaches the Thymio B;

SYS14-M: Thymio A after completing the overtake must turn around after 10 seconds;

SYS15-M: Thymio A must stop when it reaches the start of the road;

SYS16-M: Thymio B must stop when it reaches the end of the road;

SYS17-M: Thymios must follow the road;

**IMPLEMENTATION REQUIREMENTS**

IMP1-R: At the start the Thymio B should be positioned 0.5 m in front of Thymio A;

IMP2-R: The Thymio B should stop for 5 seconds when encounters the Thymio A, either from the front or the back;

IMP3-M: The Thymio A must overtake from the right the Thymio B.

## Communication Viewpoint/RUI

SYS18-M: The Thymios follow the road using the bottom infrared sensor;

SYS19-M: The Thymios identify each other using the front infrared sensors;

IMP3-M: The Thymios identify the street when the bottom infrared sensors reads a value x <= 400;

IMP4-M: The Thymios identify the other Thymios when the front sensors when the front sensor reads a value y >= 300;

# Traceability matrix

|  |  |
| --- | --- |
| **Requirements from upper layer document (identify precisely the document and its version)** | **This SRS** |
| Assume a road, with 2 undivided lanes. Assume vehicles A and B on the same lane. A is in front, B is behind A starting from a certain initial distance. | USR9-M, SYS1-R, SYS4-M, SYS5-M, SYS7-M, SYS9-M, SYS10-M, IMP1-R |
| B is proceeding at a higher speed than A. | USR8-M, USR1-M, USR7-M, SYS17-M |
| When B is sufficiently close to A, it performs an overtake | USR2-M, USR5-M, USR6-M, SYS13-M, IMP2-R, IMP3-M, SYS19-M |
| 10 seconds after the overtake is complete, B (newly in front) make a 180° turn, and start moving forward (i.e., it goes towards A in a possibly colliding trajectory) | USR3-M, SYS14-M |
| A and B avoid bumping into each other. They apply a resolution, after which both A and B can proceed on their path (move forward) | USR5-M, USR6-M, SYS15-M, SYS16-M, IMP2-R, SYS19-M |

# Test Cases/Test Plan

<Define test cases for testing your features and requirements.>

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Case ID** | **Test Scenario** | **Test Steps** | **Test Data** | **Expected Results** |
| TC01 | Overtake | - Thymio A behind at a higher speed  - Thymio B in front  - Thymio A moves to the left  - Thymio A aligns to be parallel wrt B  - Thymio A go straight for 10 seconds  - Thymio A moves to the right until it reaches the road | Speed Thymio A = 300  Speed Thymio B = 200 | B in front of A, both facing the same direction |
| TC02 | Turn Around | - Thymio A is in front of Thymio B  - Both Thymios proceed forward  - Thymio A, after 10 seconds or once it reaches the end of the road, it stops  - Thymio A turns around  - Thymios continue forward facing eachother | Speed Thymio A = 300  Speed Thymio B = 200 | A in front of B, facing eachother |
| TC03 | Avoid collision and reach destination | - Thymios proceed forward  - They identify eachother  - Thymios apply the avoidance protocol  - Thymios continue going forward after avoiding collision  - Thymios reach destination | Speed Thymio A = 300  Speed Thymio B = 200 | Thymio A at the start of the road, Thymio B at the end of the road |

## Test Cases/Test Plan Traceability Matrix

<Test cases must be traced to requirements, to prove that all requirements have been considered for testing, and tests have been developed whenever appropriate.>

<Note that requirements should be testable, so there must be good reasons to not have tests matched to a requirement.>

|  |  |
| --- | --- |
| **SRS Requirements** | **Test Cases** |
| USR1-M, USR2-M, USR5-M, USR6-M, USR7-M, USR8-M, USR9-M, SYS13-M, IMP2-R, IMP3-M, SYS18-M, SYS19-M | TC01 |
| USR3-M, USR4-M, SYS6-R, SYS14-M | TC02 |
| USR5-M, USR6-M, SYS11-M, SYS15-M, SYS16-M | TC03 |