Self-driving Car Model

System Functionality[1]

|  |  |  |
| --- | --- | --- |
| Sense | Ultrasonic | Sensing is the ability to accurately perceive the environment around the vehicle. |
| Lidar |
| Radar |
| Camera |
| Plan | On-board computer system | Planning, commonly referred to as driving policy, is where decisions are made about what strategic (i.e. change lanes) and tactical (i.e. overtake the blue car) decisions to take. |
| Act | Power system | Acting is the issuance of the decision (translated into mathematical trajectories and velocities) to the various actuators within the vehicle to perform the driving decision. |
| Breaking system |
| Steering system |
| … |

Sensing Coverage

|  |  |
| --- | --- |
| Sensing Coverage | Front |
| Rear |
| Left |
| Right |

Sensing range

|  |  |  |  |
| --- | --- | --- | --- |
| Sensor | Range | Under the influence of | coverage |
| Ultrasonic | <2m |  | Front, Rear |
| Lidar | <200m | Weather | Omni-directional |
| Radar | <50m (Short range) |  | Omni-directional |
|  | <250m (long range) |  | Front |
| Camera | TBD | Illuminance and weather | Omni-directional |

Actions of car

|  |  |
| --- | --- |
| Action of car | Start |
| Left steering |
| Right steering |
| Acceleration |
| Cruise |
| Breaking |
| Reversing |

Speed modes (TBD)

|  |  |
| --- | --- |
| Stop | 0 |
| Slow | 1, 2 |
| Fast | 3, 4 |
| Limited | 1≤speed limit≤4 |

Traffic rules

|  |  |
| --- | --- |
| Traffic rules | Speed limit |
| No lane changing |
| No overtaking |
| … |

Other agents

|  |  |
| --- | --- |
| Other agents | Front car |
|  | Rear car |
|  | Left car |
|  | Right car |

Relationship between cars

|  |  |
| --- | --- |
| Invisible | Out of sensing range, or visibility of sensors is blocked by occlusion |
| Far longitudinal/ lateral distance |  |
| Normal longitudinal/ lateral distance |  |
| Narrow longitudinal/ lateral distance |  |
| Dangerous longitudinal/ lateral distance |  |
| Collision |  |

**Scenario 1 Left Lane Cruise**

Traffic model:

Two lanes

|  |  |
| --- | --- |
| Left lane | Traffic lane |
| Right lane | Emergency lane |



Three car models:

|  |  |
| --- | --- |
| Front car |  |
| Target car |  |
| Rear car |  |

Distance control:

|  |  |
| --- | --- |
| Front | Enabled |
| Rear | Enabled |
| Left | Disabled (No left lane when cruise) |
| Right | Disabled (In this scenario there is no car on the right (emergency) lane when cruise) |

Initial parameters

Front car:

|  |  |
| --- | --- |
| Position | Left lane |
| Front |
| Speed mode | Slow |
| Enabled actions | Acceleration |
| Cruise |
| Breaking |
| Disabled actions | Start |
| Left steering |
| Right steering |
| Reversing |
| Enabled speed modes | Slow |
| Fast |
| Limited |
| Disabled speed mode | Stop |

Target car:

|  |  |
| --- | --- |
| Position | Left lane |
| Middle |
| Speed mode | Slow |
| Enabled actions | Acceleration |
| Cruise |
| Breaking |
| Right steering |
| Disabled actions | Start |
| Left steering |
| Reversing |
| Enabled speed modes | Stop |
| Slow |
| Fast |
| Limited |

Rear car:

|  |  |
| --- | --- |
| Position | Left lane |
| Rear |
| Speed mode | Slow |
| Enabled actions | Acceleration |
| Cruise |
| Breaking |
| Disabled actions | Start |
| Left steering |
| Reversing |
| Enabled speed modes | Slow |
| Fast |
| Limited |

Initial time

t = 0

Initial situation

Front car

Ordinate y = TBD

Abscissa x = 0

Target car

Ordinate 0

Abscissa x = 0

Rear car

Ordinate y = TBD

Abscissa x = 0

The target car can get following information

1. Velocity
2. Acceleration
3. Distance

Some of the unstable/unsafe situations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 1 | Speed | Fast | Fast | Fast |
| Action | Cruise | Cruise | Accelerate |
| Distance |  | - |  |
| Subsequent unsafe situation 1a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 1b | Action | - | Cruise | - |
| Distance |  | - |  |
| Subsequent unsafe situation 1c | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 2 | Speed | Fast | Fast | Fast |
| Action | Break | Cruise | Cruise |
| Distance |  | - |  |
| Subsequent unsafe situation 2a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 2b | Action | - | Cruise | - |
| Distance |  | - |  |
| Subsequent unsafe situation 2c | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 3 | Speed | Fast | Fast | Fast |
| Action | Break | Cruise | Accelerate |
| Distance |  | - |  |
| Subsequent unsafe situation 3a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 3b | Action | - | Cruise | - |
| Distance |  | - |  |
| Subsequent unsafe situation 3c | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 4 | Speed | Fast | Fast | Fast |
| Action | Cruise | Cruise | Cruise |
| Distance |  | - |  |
| Subsequent unsafe situation 4a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 4b | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 5 | Speed | Slow | Slow | Slow |
| Action | Cruise | Cruise | Accelerate |
| Distance |  | - |  |
| Subsequent unsafe situation 5a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 5b | Action | - | Cruise | - |
| Distance |  | - |  |
| Subsequent unsafe situation 5c | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 6 | Speed | Slow | Slow | Slow |
| Action | Break | Cruise | Cruise |
| Distance |  | - |  |
| Subsequent unsafe situation 6a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 6b | Action | - | Cruise | - |
| Distance |  | - |  |
| Subsequent unsafe situation 6c | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 7 | Speed | Slow | Slow | Slow |
| Action | Break | Cruise | Accelerate |
| Distance |  | - |  |
| Subsequent unsafe situation 7a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 7b | Action | - | Cruise | - |
| Distance |  | - |  |
| Subsequent unsafe situation 7c | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 8 | Speed | Slow | Slow | Slow |
| Action | Cruise | Cruise | Cruise |
| Distance |  | - |  |
| Subsequent unsafe situation 8a | Action | - | Acc | - |
| Distance |  | - |  |
| Subsequent unsafe situation 8c | Action | - | Break | - |
| Distance |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 9 | Speed | Slow | Slow | Fast |
| Action | Cruise | Cruise | Cruise |
| Distance |  | - |  |
| Subsequent unsafe situation 9a | Action | - | Acc | - |
| Distance 1 |  | - |  |
| Subsequent unsafe situation 9b | Action | - | Cruise | - |
| Distance 2 |  | - |  |
| Subsequent unsafe situation 9c | Action | - | Break | - |
| Distance 2 |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 10 | Speed | Slow | Slow | Fast |
| Action | Break | Cruise | Cruise |
| Distance |  | - |  |
| Subsequent unsafe situation 10a | Action | - | Acc | - |
| Distance 1 |  | - |  |
| Subsequent unsafe situation 10b | Action | - | Cruise | - |
| Distance 2 |  | - |  |
| Subsequent unsafe situation 10c | Action | - | Break | - |
| Distance 2 |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 11 | Speed | Slow | Slow | Fast |
| Action | Cruise | Cruise | Accelerate |
| Distance |  | - |  |
| Subsequent unsafe situation 11a | Action | - | Acc | - |
| Distance 1 |  | - |  |
| Subsequent unsafe situation 11b | Action | - | Cruise | - |
| Distance 2 |  | - |  |
| Subsequent unsafe situation 11c | Action | - | Break | - |
| Distance 2 |  | - |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Front car | Target car | Rear car |
| Unstable situation 11 | Speed | Slow | Slow | Fast |
| Action | Cruise | Cruise | Accelerate |
| Distance |  | - |  |
| Subsequent unsafe situation 11a | Action | - | Acc | - |
| Distance 1 |  | - |  |
| Subsequent unsafe situation 11b | Action | - | Cruise | - |
| Distance 2 |  | - |  |
| Subsequent unsafe situation 11c | Action | - | Break | - |
| Distance 2 |  | - |  |