Backup Rollover Requirements
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Overview

“NHTSA has identified a total population of 228 fatalities and 17,000 injuries due to light vehicle backover crashes” (22, NHTSA). These accidents are preventable, and with the correct safety precautions detailed in this paper, they can be avoided (Lombardi). The Backup Rollover system is designed to prevent backup collisions, especially in the case where a person is injured. In fact, each week, at least two children are killed and many more injured in backover accidents, often caused by relatives (Associated Press). The Backup Rollover system will ultimately provide drivers, pedestrians, and families with a sense of safety. The system will offer an auditory and visual warning when the driver is approaching a pedestrian or object in reverse. In extreme cases, the Backup Rollover system will intervene, applying emergency brakes if the warning is dismissed and a collision is imminent. Finally, the onboard display on the dashboard will provide the driver with a more accurate display of the vehicle’s rear.

Functional Requirements

The Backup Rollover system is designed to keep families and pedestrians safe by using advanced sensors, object-recognition, and real-time video displays to give drivers accurate warnings and in some cases, mitigation. The system will be equipped with three sensors on the rear of the vehicle, each specializing in identifying a different type of collision. For example, radar sensors have poor performance when detecting small children but detect pedestrians well overall (42, NHTSA). On the other hand, infrared can detect humans of all sizes by sensing body warmth but may miss inanimate objects (580, Giles). Each sensor will compensate for the other sensors’ shortcomings. This not only ensures the safety of pedestrians, but provides a safeguard in case of a sensor failure.

Not only does the system detect objects and alert the driver of their presence on an LCD display, but The Backup Rollover system is capable of mitigation. Driver override is then required to release the system’s control, preventing single-person collisions. In cases where collisions are less likely, auditory and visual warnings are administered. The driver is informed by the display but if a collision is very likely the system will take over before even the driver notices the obstacle.

FR1. Sensors

FR1.1 Cameras
FR1.1.1 On the rear bumper of the car there are two video cameras, an infrared camera and a general purpose camera.

FR1.1.2. Each camera’s field of vision includes: a width of 10 ft at the bumper of the vehicle which widens to a width of 20 ft at 6 ft behind the bumper (48-49, NHTSA), a height of 32 inches (52, NHTSA), and a depth of 20 feet.

FR1.1.3. Both cameras are processed by a computer vision object recognition software element in real time.

FR1.1.3.1. The involved software will conduct image segmentation to identify obstacles and categorize them as high priority if a human obstacle is detected.

FR1.1.3.2. The infrared camera, used as night-vision (580, Giles), will be the primary sensor at night as it is better equipped for the given conditions.

FR1.2. Radar sensor
FR1.2.1. The 76.5GHz radar will operate as the tertiary sensor used to identify objects that have been missed by the cameras.
FR1.2.2. The radar will use the direct propagation method to determine the distance an object is from the vehicle (Clemson University).

FR2. Display and Speaker

FR2.1. LCD Display
   FR2.1.1. An LCD display screen will be installed on the car’s dashboard. This screen will display the general purpose camera feed as well as system messages.
   FR2.1.2. The video feed will have an overlay which identifies distance of behind car. A marker will be present at least every 5 feet.

FR2.2. Display Messages
   FR2.2.1. If any sensor detects an object within 10 feet, a warning is displayed, “Obstacle Detected! Begin Braking.”
   FR2.2.2. When the transmission is put in reverse, the LCD will display, “Disclaimer: System is More Accurate if Backing Up Under 10 mi/hr.”
   FR2.2.3. If a sensor has malfunctioned or is obstructed an error is displayed, “Check Bumper for Camera Obstruction and Remove. If Problem Persists, Take Into Manufacturer For Repair.”

FR2.3. Speaker Messages
   FR2.3.1. Beeping occurs based on the distance from the approaching obstacle.
   FR2.3.2. As the vehicle approaches an obstacle, the beeps will speed up. The frequency of beeps is based on the distance from the nearest obstacle.
   FR2.3.3. Beeping will be connected to the car’s stereo system.
   FR2.3.4. Each time a visual message is displayed on the LCD interface, a single beep will alert the driver.

FR3. Mitigation and User Override

FR3.1. Mitigation: If an obstacle is detected within 3 seconds of trail distance by any of the sensors, the vehicle will apply the emergency brakes.

FR3.2. User Override
   FR3.2.1. When the emergency brakes are applied to avoid a collision, the driver must navigate to the LCD screen found on the dashboard to release the emergency brakes.
      FR3.2.1.1 If the driver’s foot is not on the brakes, a message is displayed, “Emergency Brakes Applied! Collision Avoided. Engage Brakes to Disable.” The system will then ask, “Is It Safe to Release the Emergency Brakes?”
      FR3.2.1.2. If the driver’s foot is on the brakes, the message on the LCD screen will read “Emergency Brakes Applied! Collision Avoided. Is It Safe to Release the Emergency Brakes?”
      FR3.2.1.3. If the user selects release, the system will ask “Are You Sure?” before releasing the emergency brakes.
      FR3.2.1.4. If the user selects to not release the emergency brakes, the system will return to the message screen.
**FR4. Vehicle Specifications:** The system can only be installed on light, passenger vehicles without a trailer.

**Nonfunctional Requirements**

The Backup Rollover system should be designed as a high assurance system. In order to guarantee safety, the system should possess specific qualities such as ease of use and high fault tolerance. The nonfunctional requirements below will act as fail-safes to many possible, although not necessarily probable, malfunctions or issues. Design of the system should also keep performance and maintainability in mind, so if better sensors or object recognition algorithms are developed they can easily be added to the system. The Backup Rollover system’s main focus is on the physical well being of drivers and pedestrians but it should also consider security issues and crash data to be used in the event of a lawsuit.

**NFR1. Cameras**

- **NFR1.1.** If a sensor fails, whether by some barrier or a hardware malfunction, the other sensors will still detect an obstacle.
- **NFR1.2.** The image segmentation component of the system should be robust to noise.
- **NFR1.3.** The cameras should be protected against a light rear-end crash. This can be accomplished by embedding the cameras inside the bumper and/or by some plexiglass covering.

**NFR2. Display and Speaker**

- **NFR2.1.** Messages will not cover video feed on the LCD screen, unless the video feed has malfunctioned.
- **NFR2.2.** The system will identify hardware malfunctions and notify the driver through the LCD display.

**NFR3. Mitigation and User Override**

- **NFR3.1.** After an obstacle is detected in the 3 second trail distance of the car, the system will apply the emergency brake as smoothly as possible.
- **NFR3.2.** The emergency brakes should not stay locked if override is requested by the user.

**NFR4. Security:** The system will only allow updates and its functionality can only be disabled when the correct 2-factor authentication is used from the manufacturer.

**NFR5. Performance**

- **NFR5.1.** The system’s detection computation will not exceed the response time of 0.35 seconds (NHTSA, 43).
- **NFR5.2.** The display’s image will not exceed the response time of 1.25 seconds (NHTSA, 120).

**NFR6. Interoperability**

- **NFR6.1.** The system will communicate with the speakers on the vehicle to relay its auditory warnings.
- **NFR6.1.1.** The only time the system will take control of the speakers is to administer warnings.
- **NFR6.2.** The system will communicate with the brakes on the vehicle to send a command to apply emergency brakes if necessary.
NFR6.2.1. The only time the system will be able to send a command to the brakes is if a sensor has detected a collision.

NFR7. Availability: The system will only be active when the vehicle is in reverse.

NFR8. Capacity
   NFR8.1. The system will be able to store up to 1 minute of data from each sensor.
   NFR8.1.1. The camera will store data in the form of images.
   NFR8.1.2. The radar will store data in the form of a log listing whether an object was detected and the distance from that object, if any.
   NFR8.2. The system will discard data after 30 seconds.

NFR9. Recoverability
   NFR9.1. The only time the system will store data is if a collision occurs. The system will store the 10 seconds of data prior to the collision.
   NFR9.1.1. The data will be stored on an internal drive.

NFR10. Serviceability: Hardware and software changes may only be completed by an authorized manufacturer.

NFR11. Maintainability
   NFR11.1. The system is capable of hardware upgrades to a higher resolution camera as well as a higher GHz radar.
   NFR11.2. The software can be altered to accommodate changes when hardware is added or update software performance if necessary.

Bibliography