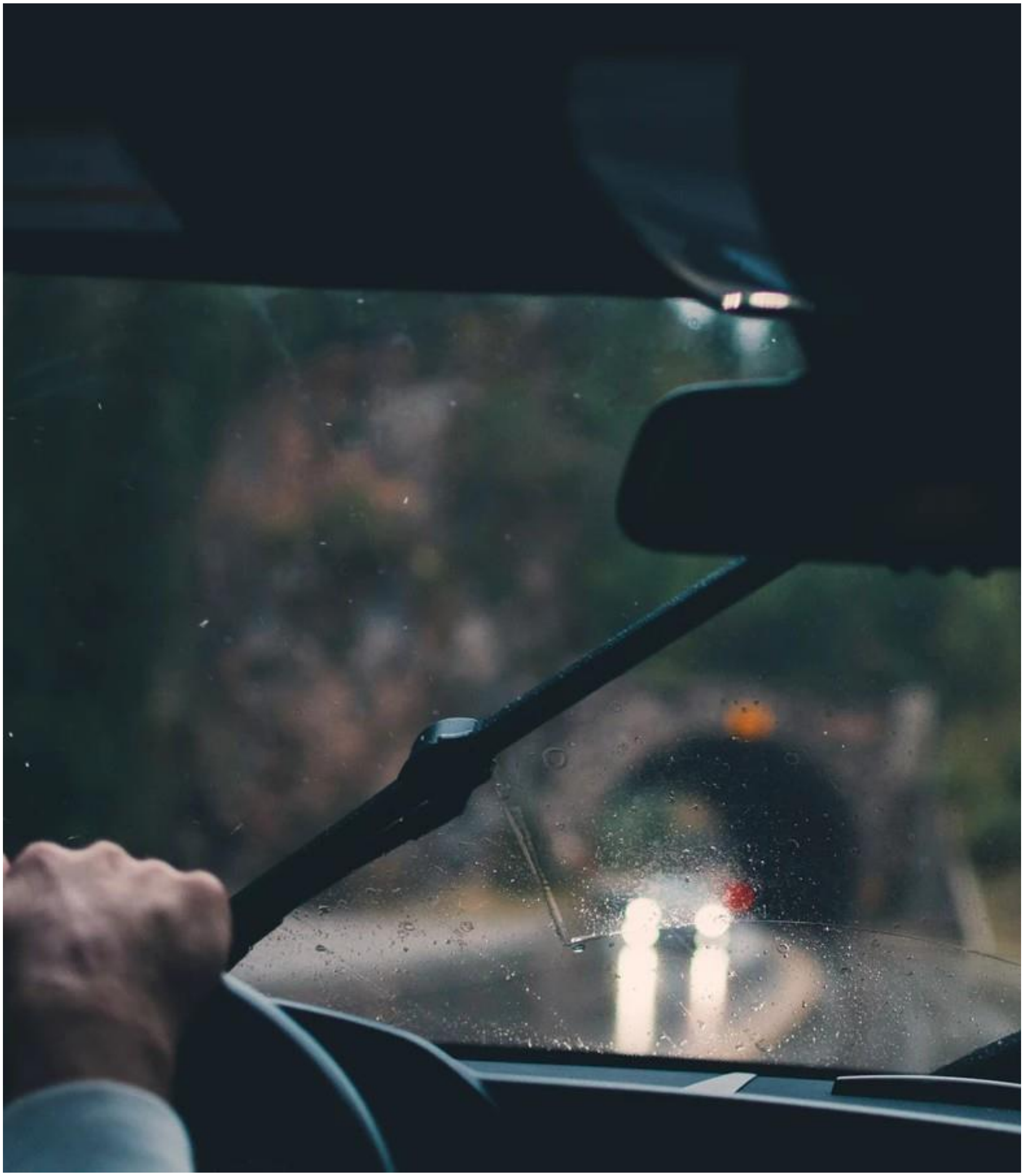


Project Final Prototype

Car Accidents Caused by Low Visibility

Members: Ziruo Ke, Ted Chan, Yu-Ting Huang, Yvan Sun, Zhiyang Li

Introduction - Reduce Road Traffic Accidents Caused by Low Visibility

Road traffic accidents happen every day, and a large portion of them are caused by low visibility. These accidents are costly to the economy and can be emotionally detrimental to the victim’s friends and families. Unfortunately, there is not a widely adopted solution that addresses the risks caused by low visibility. Our team will be looking into solutions to alleviate visibility-based road accidents.

Our team conducted user interviews, surveys, and research on U.S. drivers to better understand the pain-points they are facing during driving. The research result showed that low visibility driving conditions do in fact impact a person’s driving ability by a considerable amount and can lead to road traffic accidents. Our team aims to design a solution that is technically feasible, economically viable, and highly adaptable to all drivers. Our solution also needs to solve problems caused by multiple low visibility conditions (low light, heavy rain, thick fog etc.) instead of focusing on one specific circumstance.

User Research/Information Problem

During our user research phase, we conducted a survey with 140 respondents and two user interviews (one experienced driver and one novice driver) to better understand our users.

Survey and Interview Results

Among our survey respondents, the majority participants have been driving for less than a year (46.1%) while 38.8% participants have one to three years of driving experience. However, almost all survey participants have experienced low visibility conditions in different cases such as snow, rain, fog, and low light while driving.

Of all low visibility driving conditions, 36.7% drivers feel that snow impacts their driving ability the most, 31.7% think that fog is most impactful while 13.3% believe that low light has the most impact. Moreover, 68.1% of drivers encountered confusing pavement marks while driving, and 71.9% of them have had experience driving at night without street lights.

Our survey results and interviews with both experienced and novice drivers showed that low visibility driving conditions impact both user groups, regardless of tenure of driving. The general consensus is that existing solutions leave much room for further improvements as they are not universally adaptable to every low visibility driving condition and may not work as well in the long term.

Problem

Based on our survey and interview results, we constructed a list of problems that drivers face during low visibility driving conditions.

- Low visibility caused by heavy rain
    - Wet ground makes markings less visible
    - Physically lower visibility
    - Increased reaction time due to low visibility and lower level of control
- Low visibility caused by snow
    - Snow covers marking on the ground and signages on the streets
    - Physically lower visibility
    - Decreased level of control due to less traction
- Low visibility caused by thick fog
    - Decreased visibility due to fog
    - Inability to use high beam in the situation (reflection from the fog)
- Low visibility caused by low light
    - Some roads have no street lights
    - Broken street lights or traffic lights
    - Other cars driving without lights on (hard to see them in the dark)
- General inability to distinguish lanes due to weather conditions or poor pavement markings
- General inability to spot objects that suddenly appear on the road (animals/ pedestrians)
- General inability to read traffic signs due to low visibility conditions
- General inability to see other cars and distinguish distance between traffic due to low visibility
- General inability to see road/terrain due to low light situations

Our Solution - Standalone HUD Unit

Our solution of a standalone HUD unit will utilize a lot of the existing technologies adopted in autonomous cars to tackle the issues presented by low visibility driving conditions.

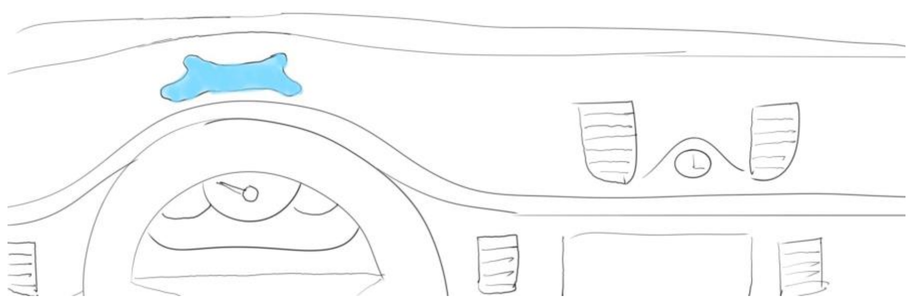
While driving in low visibility condition, our HUD product can act as an extra set of eyes that can see more accurately on the road. A lot of the problems created by low visibility driving condition can be mitigated with spatial mapping and computer visioning. Autonomous cars utilize an array of sensors and systems (front camera, laser range finder, proximity sensor, GPS, ultrasonic sensors etc.) to generate a 3-D mapping of its surrounding environment.

We plan to implement some of these sensors and systems into our HUD product as well. However, due to size and compatibility restrictions, not all sensors are able to be directly implemented into the HUD unit, thus we foresee that additional sensor modules may be purchased and installed on the outside of the vehicle (ultrasonic sensors in wheels, additional laser range finders on car roof, etc.) to provide a more comprehensive experience. However, for the scope of our project, we will only focus on capabilities that can feasibly be achieved with the HUD unit itself.

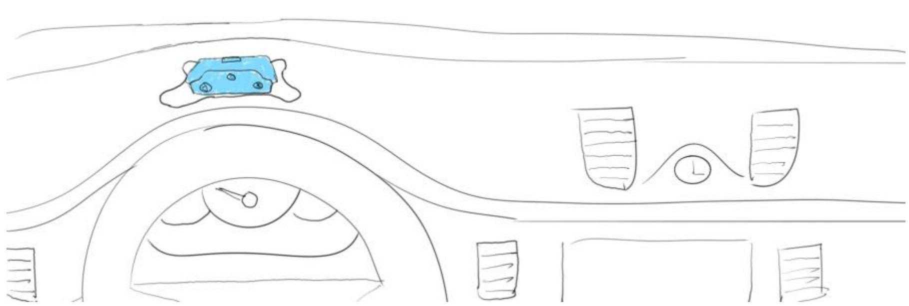
User Interaction

The main interaction between users and the HUD unit will be through voice and sound.

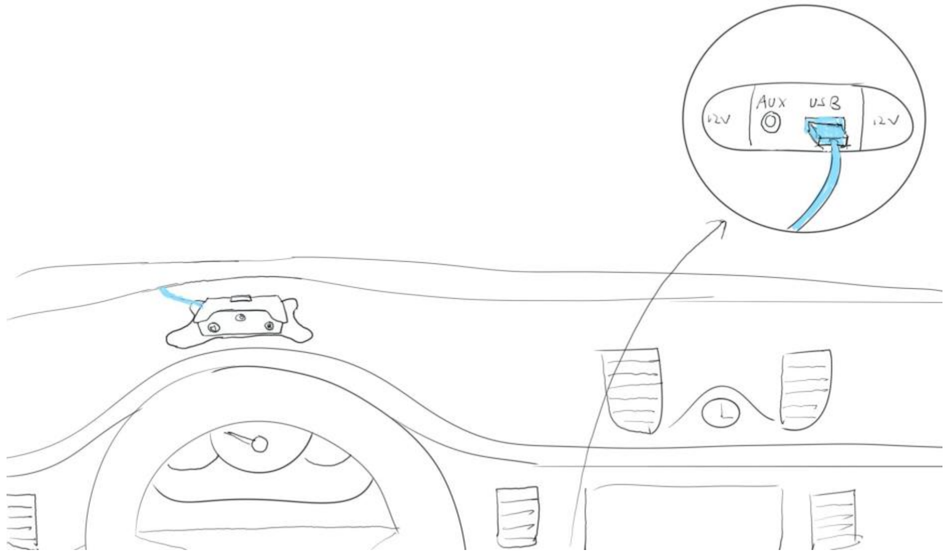
Step 1: Install the sticky pad onto dashboard. This will act as a secure base for the HUD



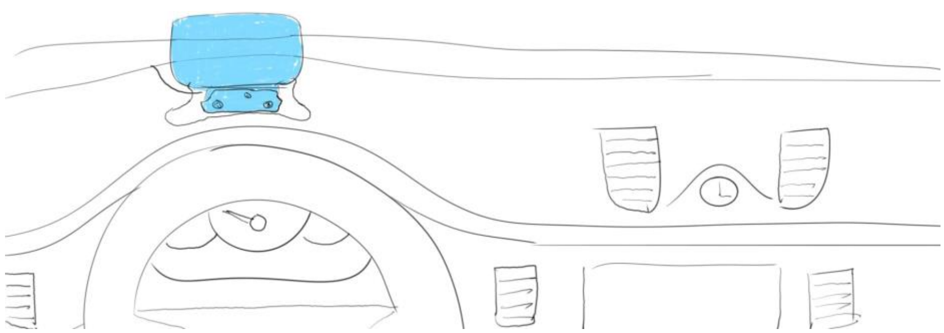
Step 2: Attach HUD to sticky base



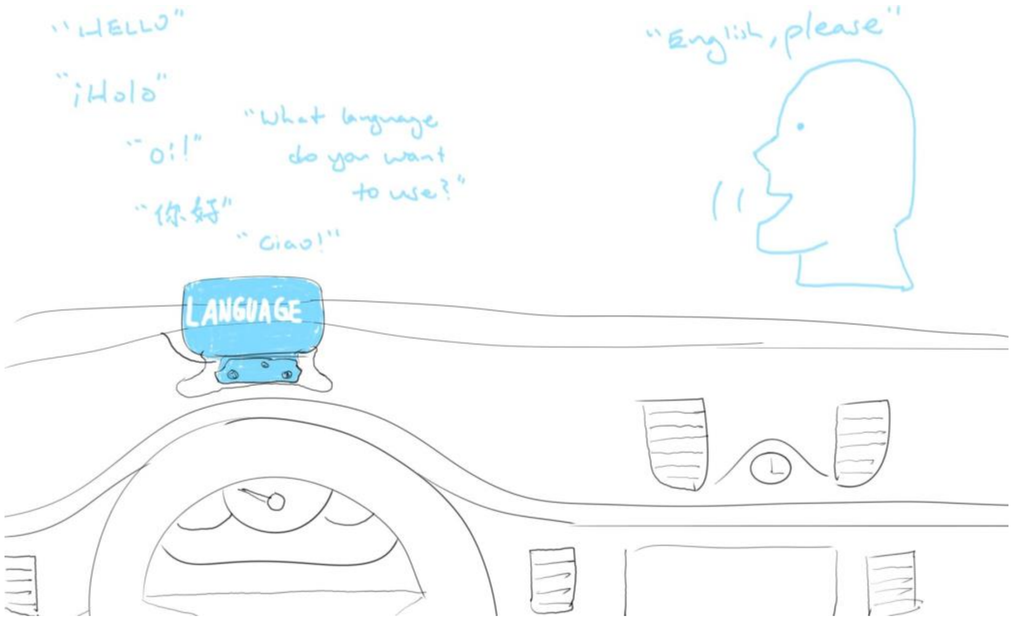
Step 3: Plug in power to power up the HUD unit



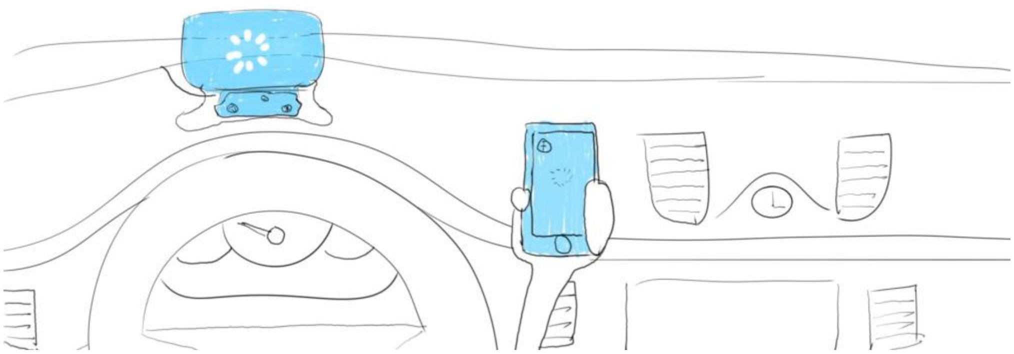
Step 4: Flip the screen up to turn the unit on



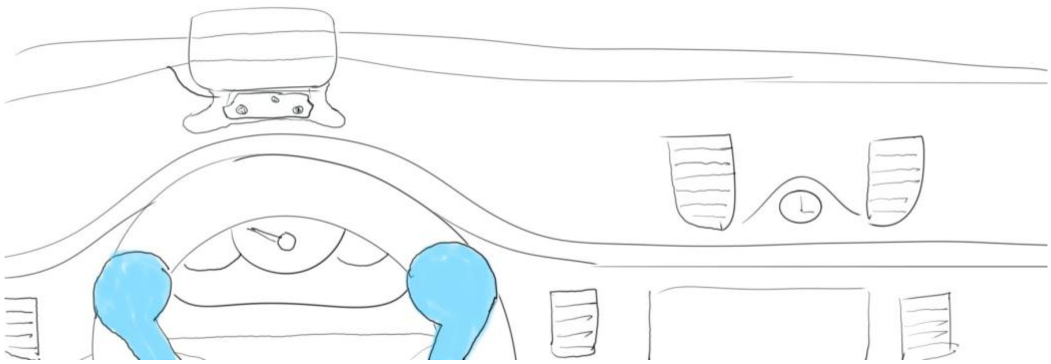
Step 5: Configure language settings by speaking the language to the HUD unit



Step 6: Connect phone to the unit through bluetooth to push navigation and multi-media information to the HUD unit



Step 7: Start driving and the HUD unit will prompt different interactions based on the scenario. Detailed interface is documented in the later section

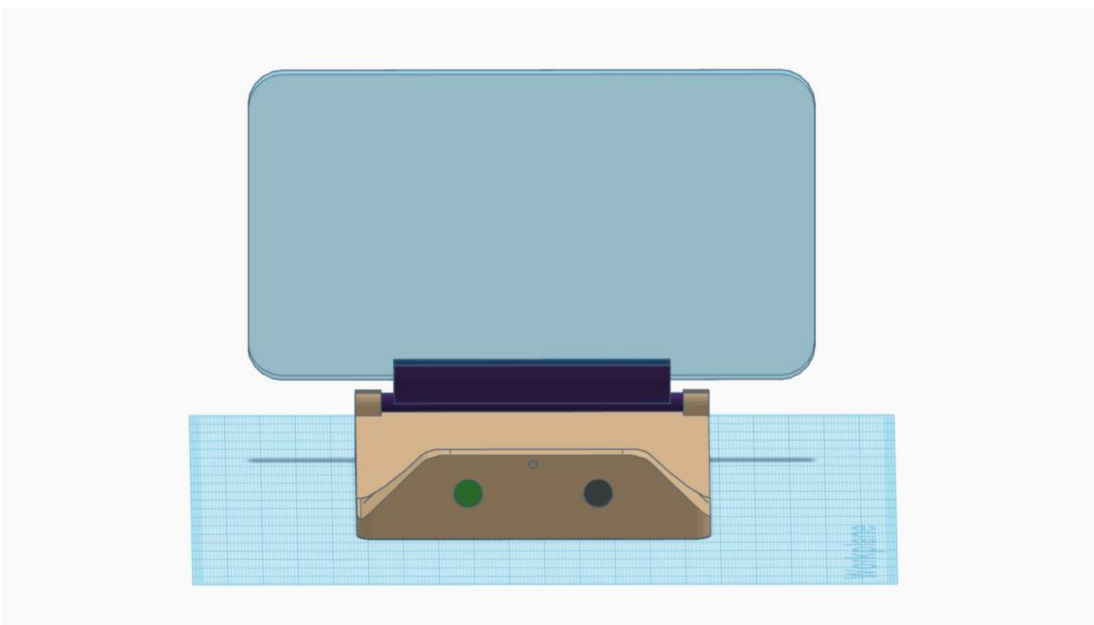


Hardware Prototype

Design

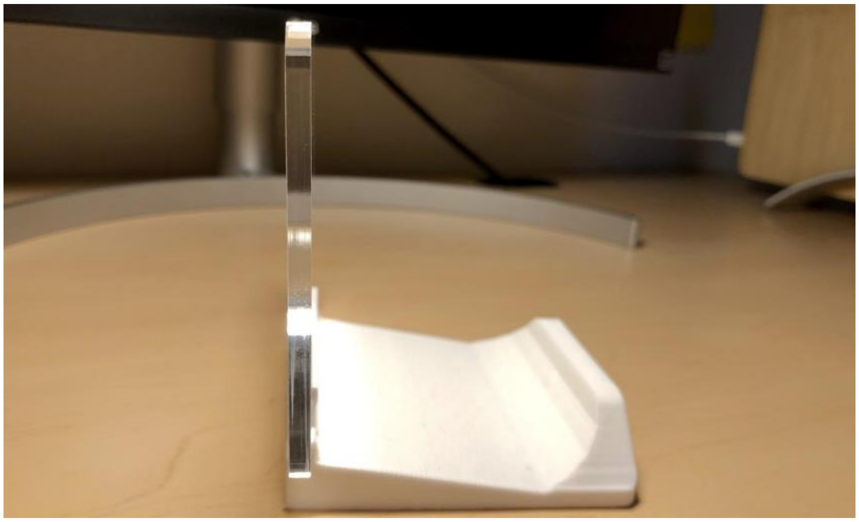
The standalone HUD unit is designed to sit above the vehicle instrument cluster and right in front of the driver's field of vision. The unit will come in two parts: first the actual HUD unit itself, and secondly, an adhesive base that can stick onto the dashboard and connect to the HUD unit. This ensures maximum universal compatibility with a broad range of vehicles.

We used CAD software to construct a 3D model of our product and printed it with a 3D printer.



(3D model of our prototype)

The overall design of the unit is straightforward and consists of minimum interactive buttons. The primary interaction method with the device would be through voice commands. This is in consideration of the safety of the driver and the usability of the device while the user is operating the vehicle. The front of the device will consist of a camera (to detect fatigue and provide warning), a microphone button that activates voice commands, and a speaker button that can toggle sound on or off.



(Side of the HUD unit)

There are no interactive features on the side of the device. The device will automatically turn on when the user lifts the HUD glass and turn off when the user puts the piece of glass down. Volume up/down buttons and projection brightness up/down buttons will be located on top of the device (not printed in the model due to technical issues).

(Back of the HUD unit)

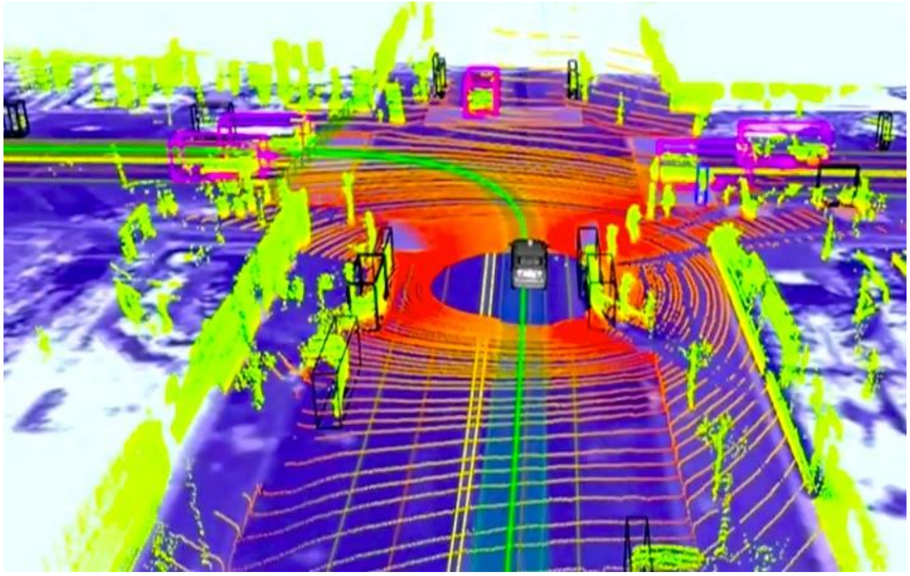
There are no interactive features on the back of the unit. The back of the unit consists mostly of all the sensors and cameras that are used to power our solution. There will be multiple cameras to provide depth analysis, a laser range finder to detect length between the vehicle and objects on the road, and GPS sensor to provide real-time locational data of the vehicle.

Functions and Features of HUD Unit

The HUD device utilizes a combination of technologies to solve the information problem.

Spatial Mapping

The device utilizes a combination of cameras and sensors to create a 3D mapping of surrounding environments. This can be particularly useful in low visibility conditions caused by bad weather. Drivers might have a hard time keeping track of everything going on around them in such bad weather conditions, but the 3D mapping feature would still be able to work.

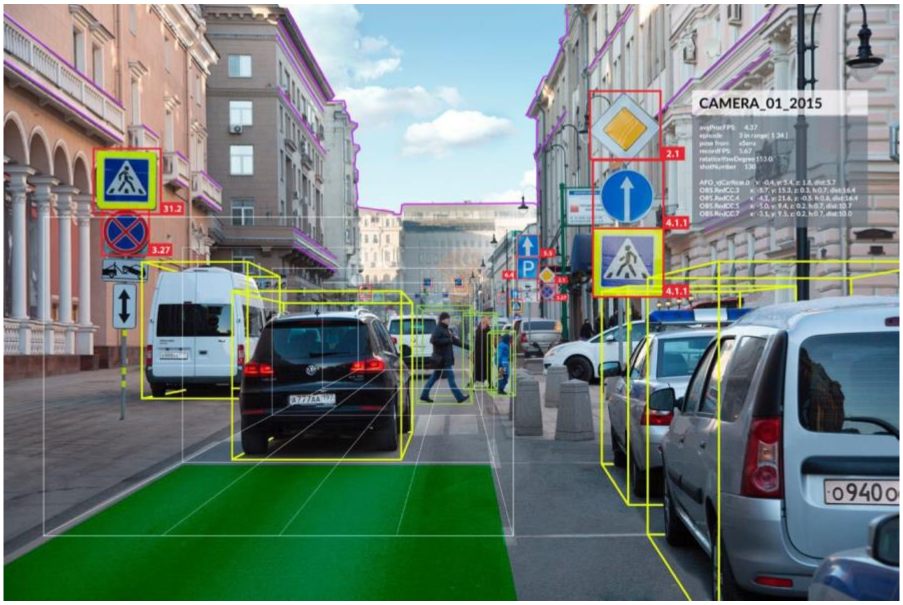


(Figure depicts 3D map technology from Google's self-driving car. Source)

Spatial mapping technology can be used to identify objects around the vehicle and the distance between them. The driver can then utilize this information to act accordingly even when they cannot see clearly in a low visibility condition.

Computer Vision

By utilizing machine learning and artificial intelligent technologies, the unit can utilize computer vision modules to identify items on the road. The HUD unit can identify lanes, street signs, traffic signs, traffic lights, and other objects such as animals and pedestrians. The unit can then provide information or warning to the driver based on the situation.



(Figure depicts driving based computer vision technology. [Source](#))

Deceleration and Braking Guidance

The device will include GPS and accelerometer sensors to predict a vehicle's trace based on the route and the vehicle's velocity and momentum. The unit can then provide warning and declaration guidance to the driver.

(Figure depicts relationship between cornering and speed. [Source](#))

Infrared Vision

Under low light conditions, the device can turn on its near-infrared camera and display a visual feedback to the driver.

(Figure depicts near-infrared technology in car. Source)

Other Secondary Features

The HUD unit is capable of solving more than just the information problems we have discovered. It can also be used to monitor the driver's engagement in driving (eye tracking with front facing camera), capture dash camera footages, display navigation, and display other general vehicle information (miles, gear, fuel level etc.). However, these features will not be our focus for this project since they do not directly impact the information problems we are tackling.

Usage Scenarios & High Fidelity Interface Prototype

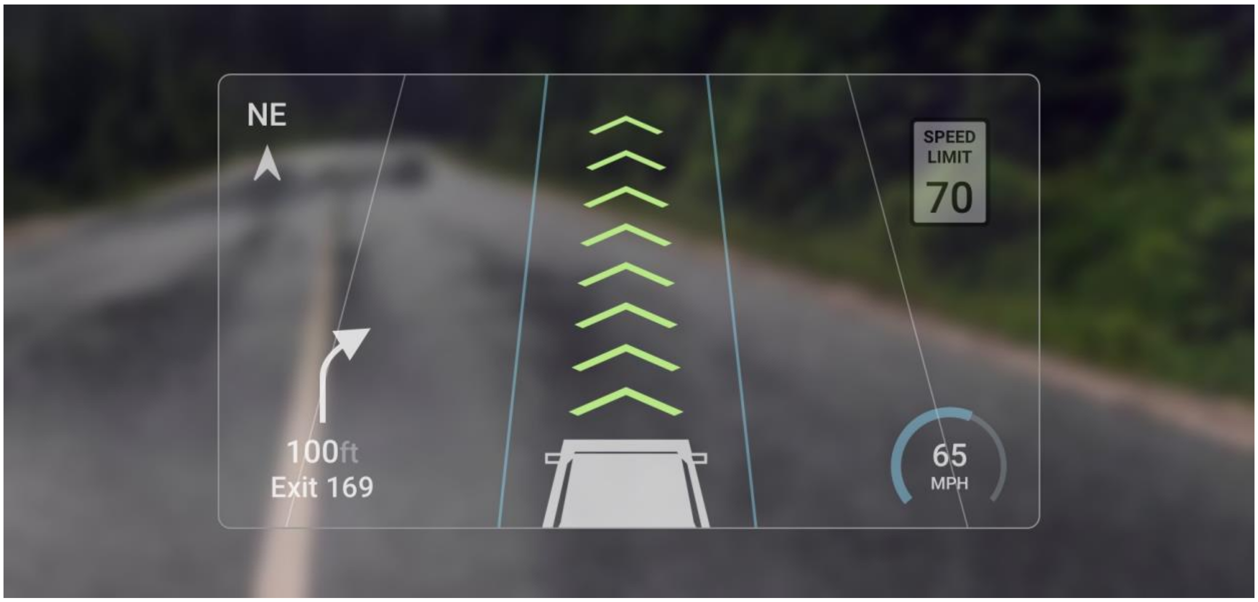
Our usage scenarios will be based on the two personas we created: Justin (an experienced driver) and Jerry (a novice driver). The detailed personas can be found in the appendix section. Justin, as a more experienced driver, face information problems that are purely related to low visibility conditions while Jerry, as a novice driver, face both problems caused by low visibility conditions as well as additional challenges presented by his lack of driving experience. Most if not all interaction with the HUD unit will be through voice control and voice feedback. Moreover, information displayed on the unit will be based on the driving situation. Therefore, we do not think that a wireframe can accurately depict the user experience. Instead, we will provide cases of low visibility information problems and illustrate how our device will help solve such problems.

Scenario Perspective - Justin Tran (Experienced Driver)

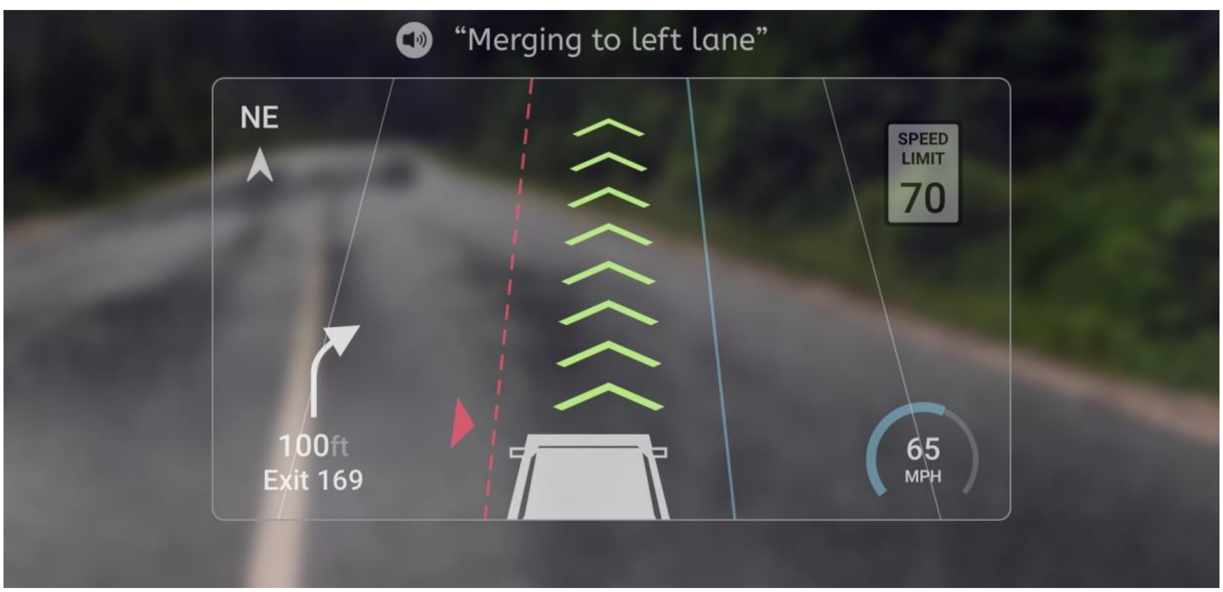
Justin Tran is a consultant working in Seattle. He is a young professional driver with over 5 years driving experience. Justin is seeking an efficient solution to deal with low visibility problem while driving.

According to Justin, he is mostly frustrated with the unclear painted signs on road especially during bad weather. By using the HUD unit our group designed, Justin could simply flip open the glass panel to turn on the device whenever he could not clearly see and differentiate painted signs on the road.

By utilizing spatial mapping and computer vision technology, our HUD device will be able to automatically project a real-time position of the car relative to the lane on the HUD. For example, it would warn Justin when the vehicle gets too close to one side of the lane or is at risk of crossing/merging into a different lane. The lane would appear dotted and will blink on the display to notify Justin of the situation. A warning sound is also played (driver can choose to disable the sound) when this happens. Future iteration/update will connect the HUD unit with the vehicle's onboard computer so that the warning stops displaying when Justin performs intention of merging lanes (activate turn signal).



(Figure depicts HUD display of vehicle position relative to lane)



(Figure depicts HUD display of lane merge warning when vehicle gets too close to one side)

Moreover, it will also project those street signals along roadsides such as Stop signs, No Entry signs, One-way signs, Roundabout signs, etc. The HUD unit will clearly display these signs on the display to notify Justin of their distance from the vehicle, so Justin no longer have to be distracted while driving trying to find signages.

(Figure depicts warning of stop sign ahead)

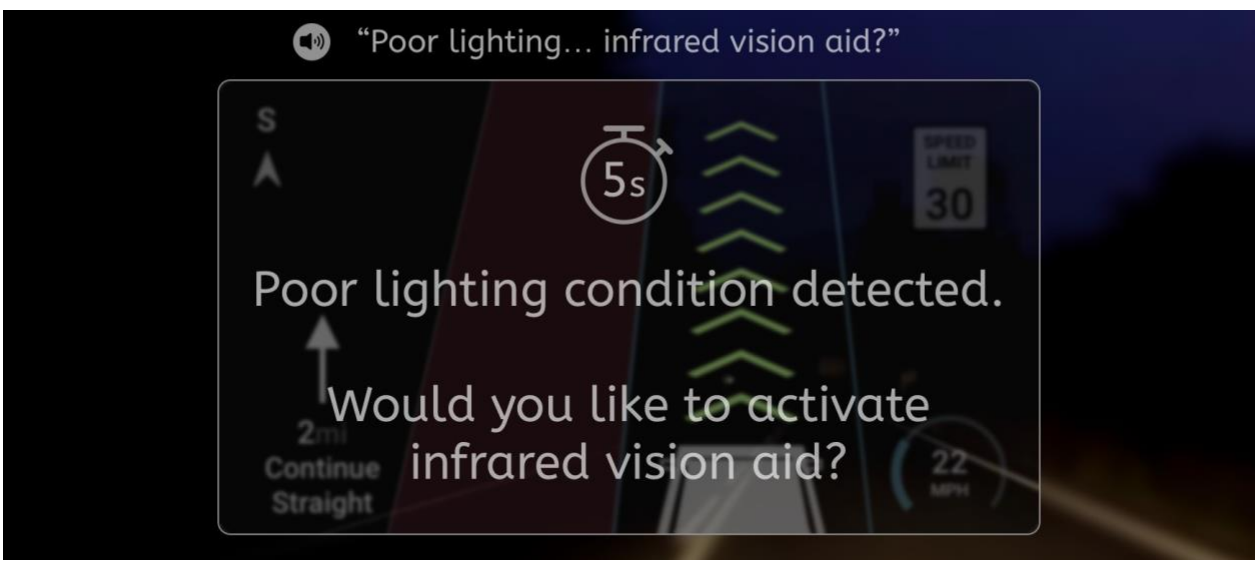
(Figure depicts warning of roundabout sign ahead)

With data gathered from the camera alone, it does not provide enough response time for Justin whenever emergency happens. This is not saying that the signage alert is bad, but it requires us to build up a dataset for collecting and updating the road signage information regularly, which could be done by computer visioning, and is something that will improve over time.

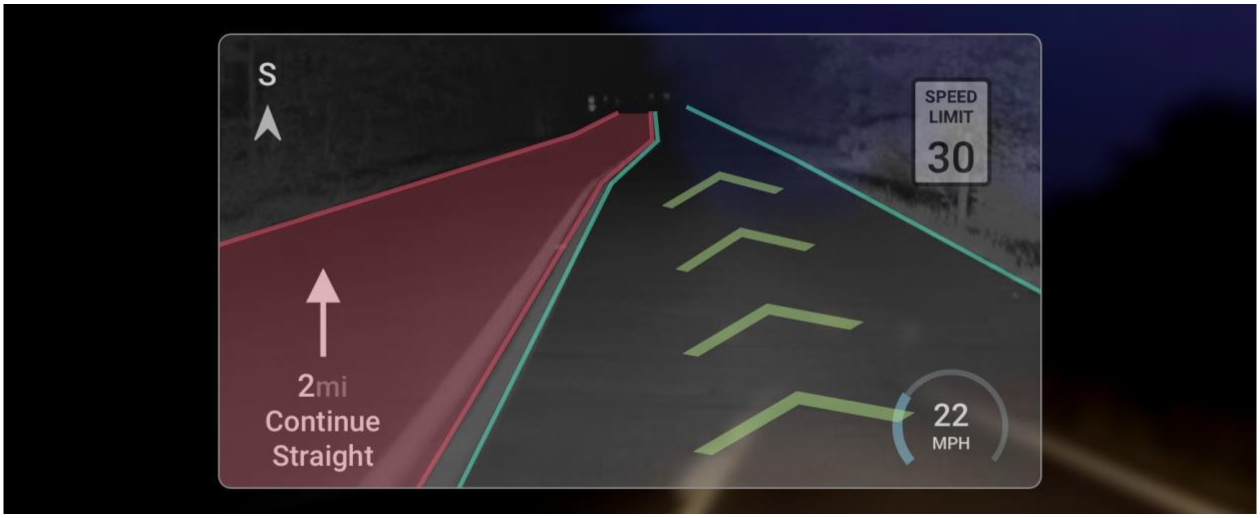
Scenario Perspective - Jerry Huang (Novice Driver)

Jerry is a student here in Washington. He is a new driver with merely half-year driving experience. Jerry said that he was affected greatly when driving on low-visibility roads especially those without street lamps or with little lighting.

When the front facing cameras detect a dark environment, our HUD unit will ask Jerry if he wants to activate the infrared visual aid. He will have 5 seconds to answer Yes or No before the unit resumes to its previous display. If he says yes, the HUD unit will send a digital video feed to the display and accurately highlight a safe driving region for him.

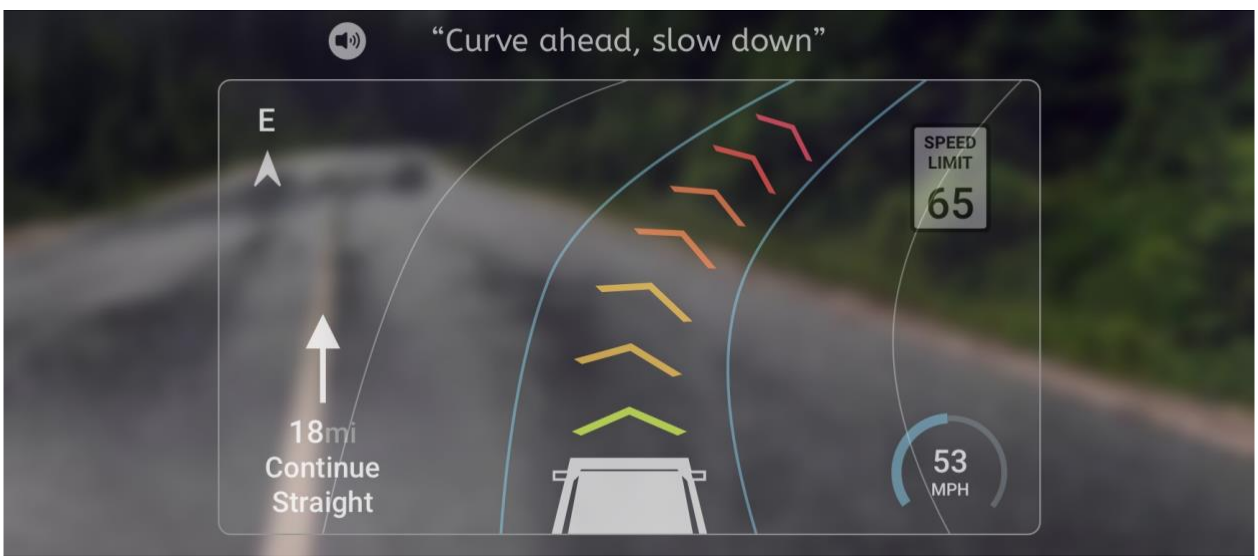


(Figure depicts the pop up asking if driver wants to activate infrared vision aid)



(Figure depicts infrared visual feed on HUD display)

Moreover, as a novice driver, Jerry is not yet experienced to control his speed around the corner, especially in low visibility conditions. Our HUD device can utilize geolocation and accelerometer sensors to measure the speed and momentum of the vehicle. It can then take into account the road condition (wet, dry, snow etc.) and provide deceleration and braking guidance to Jerry.

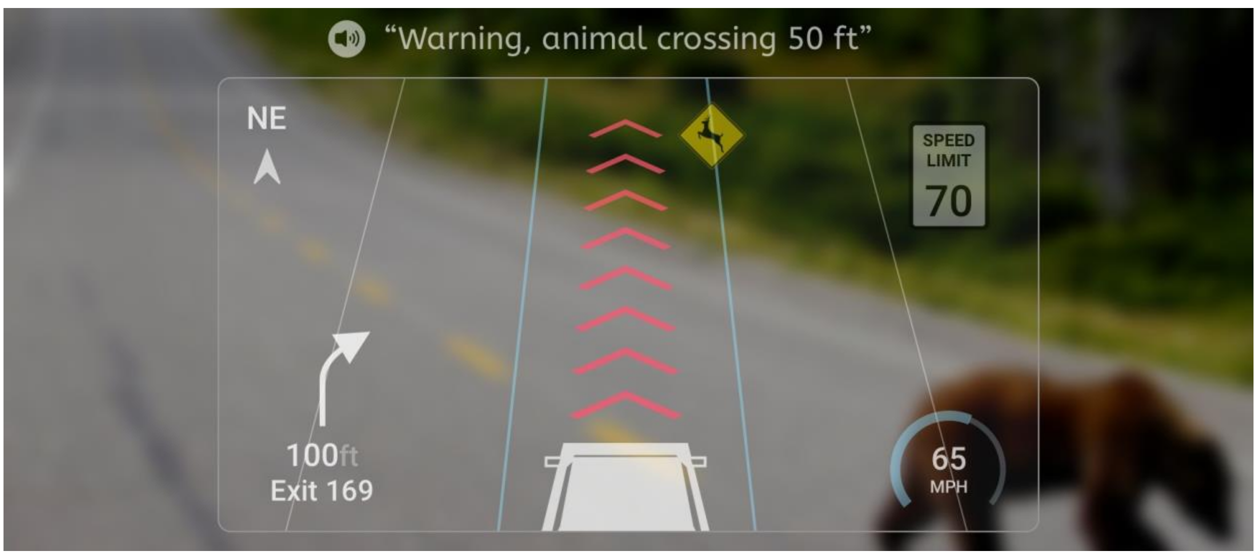


(Figure depicts deceleration guidance on HUD display)

The different colored arrows signal Jerry when he need to brake. Green means maintain current speed while red means brake.

Additionally, Jerry is also not as experienced in spotting objects that appears abruptly on the road (animals, pedestrian jaywalking, etc.). Our HUD device can utilize its spatial mapping and computer vision technology to identify these potential hazards for Jerry.

(Figure depicts warning of pedestrian crossing on HUD display)



(Figure depicts warning of animal crossing on HUD display)

The warning sign will blink when an unexpected object shows up on the road. The device can also play a warning sound to alert Jerry.

Lastly, our HUD unit can also notify Jerry of potential collisions by utilizing spatial mapping feature, laser range finder, and proximity sensors. Our device can measure the clearance between the user's vehicle and other vehicles on the road to warn Jerry of potential collision hazards.

(Figure depicts warning of potential front collision on HUD display)

(Figure depicts warning of potential side collision on HUD display)

Similarly, our HUD device can also alert potential side collisions when other vehicles unexpectedly move into Jerry's lane. A flashing warning sign would appear on screen to capture Jerry's attention and a cone that depicts proximity level of merging vehicle would also appear to provide clearance information to Jerry so that he can slow down to avoid potential collision.