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VALEO INNOVATION CHALLENGE '16

TEAM BUMPUP

PHASE 2 PROJECT FILE

TEAM BUMPUP

presents

DRIVERSITY

ABSTRACT

As the automotive industry moves towards the car of the future, tech companies are developing cutting edge systems that aim to make driving more pleasant, safer and more convenient. The variety of solutions for the same are truly diverse, ranging from biotechnology to autonomous artificial intelligent systems, all in search of a perfect complement to human behaviour. One such field is **Augmented Reality / Mixed Reality**, which has emerged dominantly as one of the most successful ways for user engagement in the last decade. And recently it's being integrated successfully in various driving applications by major automobile companies.

This project file descries the opportunities offered by incorporating augmented reality in a car to provide a completely refreshing, fun and engaging driving experience. **The aim of this project, when started, was to increase involvement of users with the real word while travelling, to make the driving experience more engaging than ever before.** Initially, in this report, we present a basic idea of the problems, and opportunity areas involved in today's driving conditions and how our proposed idea (which we decided to name **DRIVERSITY**), if implemented, would improve the same, drastically. We then gave a detailed introduction of our solution, technicalities, principles and concepts involved along with a description of our mock' up for **DRIVERSITY**'s proof of concept.


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WHAT IS THE PROBLEM?

Currently, the travelling experience in a car is largely monotonous, boring and unengaging. An average American spends **13476** hours driving every year or approximately **1.5** hours everyday (US Dept. of Transportation). That time nearly goes waste and the driver is often frustrated driving the same route, everyday. There is no solution available that makes the person to look forward sitting in a car. So overall productivity loss, time loss and energy loss occurs causing boredom and frustration throughout the travel time. According to a study conducted by University College, London, people suffering from boredom and frustration are **2.5** times more vulnerable to die early from heart diseases or strokes. Creativity and thinking ability is also affected adversely for such people.

To avoid boredom and monotonous experience of this unengaging travel time, most of the people (both drivers and passengers) use mobile phones or other such devices causing driver distraction and since cell phone usage demands visual and cognitive attention of the user, it is regarded as the worst distraction of all while driving. **17** out of **20** people use mobile phones for more than half of the journey (User interviews at Bosch UX Studio), when travelling as passengers (not driving) in a car having no engagement whatsoever with the surrounding environment or the real world. The driver data of mobile phone usage is also alarming where a study by the WHO found that **69%** of drivers in the USA had used their mobile phone while driving within the previous **30** days. Mobile usage by car drivers is fatal in many cases and according to the National Safety Council, UK, out of total **1.3** million accidents, **26%** of accidents are caused by cell phone use while driving and according to WHO, out of all road deaths in UK, **32%** are car drivers (highest) and **14%** are car passengers (3nd highest). Similarly in USA, car drivers and passengers account for a massive **47%** and **18%** of all road deaths.Coming to the environmental characteristics, **350** people die worldwide everyday due to low visibility conditions (rain, fog, heavy snow, darkness, etc) while driving (WHO).

The root cause of all the above problems is the mismanagement of travel time which the driver / passenger is not very proud of, spending routinely. Most automotive solutions are focused to make the car more efficient and powerful. Only a handful of them cater to enhance the user experience of the driver and about no solutions focus on the rest of the passengers' experience. The big picture is often ignored and the obvious is overlooked. In 2030, we believe that cars will be much more than just a vehicle, they'll be an environment in themself and travelling will be just one of the solutions.

Expected impacts after DRIVERSITY integration

Using the augmented reality system in **DRIVERSITY**, we believe most of the experience related problems stated above can be efficiently tackled. One solution will solve two purposes, that is, breaking the monotony of everyday driving in an enjoyable fashion and secondly, engaging users and letting them interact with the environment and the real world around them which they'll be missing otherwise, being engossed in their cell phones while travelling.

Gamifying the driving / travelling process would enhance the overall experience of driver and passengers alike. Be it competing and interacting with drivers around you in a virtual game while stuck in traffic or making children learn about the surrounding environment, a whole set of new possibilities is opened with **DRIVERSITY** enabling users to try new things every day, stay connected with others and appreciate the beauty of the real world. Overlaying and combining different types of digital information with the real world would highly reduce the need of external devices, preventing driver distraction and allows to focus where the user should. Infrared technology combined with the RGB cameras would help to navigate with ease in low visibility conditions, playing an important role in preventing major road accidents.

WHAT ARE THE SITUATIONS TO IMPROVE?

For a car driver, listening to music or talking to fellow passengers (if any) is the only option to overcome boredom and travel fatigue. Many drivers use a cell phone while driving for the same but it can be fatal in many cases. Similarly, for the passengers, 85% of them use cell phones for most of their travel time. In either case, that is, for the driver as well as the passenger, none of them are being truly productive. And there's a time when the music and texting becomes monotonous too. In this case, imagine the passengers and driver being served with an infotainment system that helps them be productive and have fun at the same time. Windows and windshields serve as the interfaces and users interact with the surroundings to learn, explore, play and connect with other such users in different cars around and in different parts of the world. With the power of IOT (Internet of Things) in **DRIVERSITY**, the real world becomes a live encyclopedia, a playground and a safe haven for drivers owing to its enhanced safety features. So the focus of the driver would lie where it should, a child would be able to learn about surrounding locality/automobile/etc, an elder person would get easy guidance and likewise anyone can do amazing and engaging activities out of hundreds of possibilities that **DRIVERSITY** offers, all while moving on four wheels. The novelty factor of augmented reality also plays an important role in user experience enhancement.

WHAT ARE THE CURRENT SOLUTIONS/ STATE OF THE ART?

HUDs

The leading augmented reality solution available for driving.

HUDs or Head-Up Displays were initially used to project information on a pilot's windscreen and fighter jet's pilot's helmet. HUDs are see through optical displays with graphics projected onto them and are available in a variety of different forms in the market for cars. HUDs utilize the principle of augmented reality and are now being integrated in many high end cars by auto manufacturers for ease of driving and a better travel experience. Below are some of the different approaches to a HUD in a car :

Continental HUD : High precision mirror projection from dashboard.

Pioneer HUD : Top mounted HUD.

HUDWAY : Mobile operated, small glass panel.

The limiting factor in all these HUDs is the type of information being shown to the driver. The graphics are very basic and functionalities limited. They were made to help the driver in navigation and not to give the driver a whole new fun experience along the way. User engagement and playfulness is still something that is yet to be discovered with these HUDs.

BMW MINI

The only augmented reality headset for driving.

Although there are numerous Augmented Realty headsets available in the market, providing an immersive experience to the user, not many are solely made for driving. They may have a central processing unit embedded in them or can use an external device, such as a mobile phone for the computation and camera usage. The most prominent AR headset in the driving industry is the BMW Mini based on QUALCOMM's Vuforia. This is the only headset using augmented reality just for travelling by the driver. The aim is to improve safety by eliminating blind spots, as well as helping drivers with everyday tasks such as parking. Utilizing the cameras mounted on the car, the headsetprovides an X-Ray functionality so that there are no blind spots left in case it is needed. The glasses can work as a virtual HUD with all the CGI information overlaid right on top of the field of view which is only 28 degrees. The front part of the headset features a 5 MP camera which can captures videos at 720p resolution.

Although this seems quite futuristic, but some factors are just not in favour of this headset. The overall round band and bulky frame would easily frustrate the user and it looks silly too. Moreover, being so close to the eye, an unwanted strain is constantly on the eye of the user. Lastly it only caters to the driver and not any other passenger sitting in the car. A solution is needed where the user is free from physical constraints and something that caters to the needs of all the people sitting in a car.

WHAT IS YOUR SOLUTION?

We propose an augmented reality based system for the car of 2030 named as **DRIVERSITY**. It would consist of a central computational unit, a 360 degrees RGB-D camera with light sensor on top of the car, infrared sensors, one on each door and the dashboard of the car. **DRIVERSITY** can be realized in two forms, first being for high end luxury cars where the windshield and car windows are electronically embedded transparent screens (virtual windscreen) where touch functionality may or may not be introduced (since most applications can be comfortably controlled via gesture. Second option is for low end cars where a projector would be used to project the graphics on the window/windshield and the material used would be treated glass with pixel embedment technology to capture the projected graphics with high clarity. An augmented reality headset would be a complementary accessory to this setup where the passengers can use the same when they'd like the car window to be open.

Augmented Reality : This technology is used to overlay computer generated imagery on the user's field of view of the real world to provide a composite view. In other words, it combines the real and digital world to give an immersive user experience.

IoT (Internet of Things) : IoT is a network of connected physical devices for the exchange and interpretation of data. **DRIVERSITY** would be utilizing IoT connectivity between it's different sensors and the computational unit which on the whole would be connected to the wireless internet network attempting to combine the power of internet with the interactions of the real world.

Infrared and Depth Cameras : Infrared technology is used to detect the shape, size and depth of objects in the surroundings and is most prominently used for gesture recognition, safety applications and gaming. When combined with RGB cameras (normal color cameras), they can be a mechanical alternative to human eye. Leap motion sensors, Kinect sensors, etc use the infrared technology for

virtual reality and gaming respectively. Similar sensors would be used in the **DRVERSITY** setup to recognize the gestures for UI control, sensing traffic light colors, and calculating the distance of objects around the car for safe driving.

QUALCOMM's Vuforia : Vuforia is one of the leading and most efficient augmented reality software development kits in the industry, developed by the tech giant QUALCOMM. Vuforia uses advanced computer vision to recognize and track images and basic 3D objects. Vuforia can be efficiently integrated with any operating platform and that is the reason why companies are using it for a wide variety of augmented reality applications. BMW has used Vuforia to develop Mini AR headsets for drivers and Jaguar is collaborating with them to develop next generation augmented reality virtual windscreens.

Virtual Windscreen : This technology is not yet available in the market. Many automobile companies including Jaguar, Toyota and Bosch are working to develop efficient and most important - cheap virtual windscreens to utilize the whole windscreen/windows as a head up display (HUD).
"The virtual windscreen is a concept at the moment, as the technology doesn't exist today to utilize the entire windscreen as a HUD. We are working with our suppliers to develop the technology, and are estimating it has potential to reach production in around 10 years (By 2025-2030)." - A Jaguar Land Rover spokesperson told Mashable.
The seamless and immersive experience provided by these windscreens comes at an unusual high cost and that is why this technology can only be used for the extreme high end cars but by 2030, it's very much possible that this technology would be available at a lower cost to the masses.

Pixel Embedment Technology : Few companies around the world have developed patented pixel embedment technology. (One such company is Panin Visual Technologies Pvt. Ltd.). This technology produces a treated glass which captures the graphics perfectly (being fully transparent) projected onto it via any usual projector. This can be used for the mid range cars where virtual windscreens are not affordable to install. The graphics would be projected via a powerful pocket projector installed on top of the car interior, just above the window.

Transparent Projection Film : The cheapest alternative for virtual windscreen are transparent projection films. These can be stuck on either side of glass and captures graphics projected onto it without interfering with the transparency of the glass.

AR Headset : This complementary accessory with **DRIVERSITY** wouls enable users to interact with the surroundings even when there are no windows (convertible cars) or the windows are down. The computational unit would transmit the CGI or virtual graphics to the headset which in turn would be overlaid on top of the real world view of the user.

Software required : This is where **DRIVERSITY** would stand out from any other AR automotive solutions. A whole new operating system would have to be designed solely for **DRIVERSITY** and developers from all around the world could contribute in developing innovative and intuitive driving applications. Augmented reality is still in it's early stage of advancement and one of the hottest trends as of now. Hard core development is being done in different fields of AR and having a platform for everyone would offer limitless possibilities in driving solutions as not only the automotive company but the whole automobile community around the world would be involved in developing next generation engaging driving experiences.

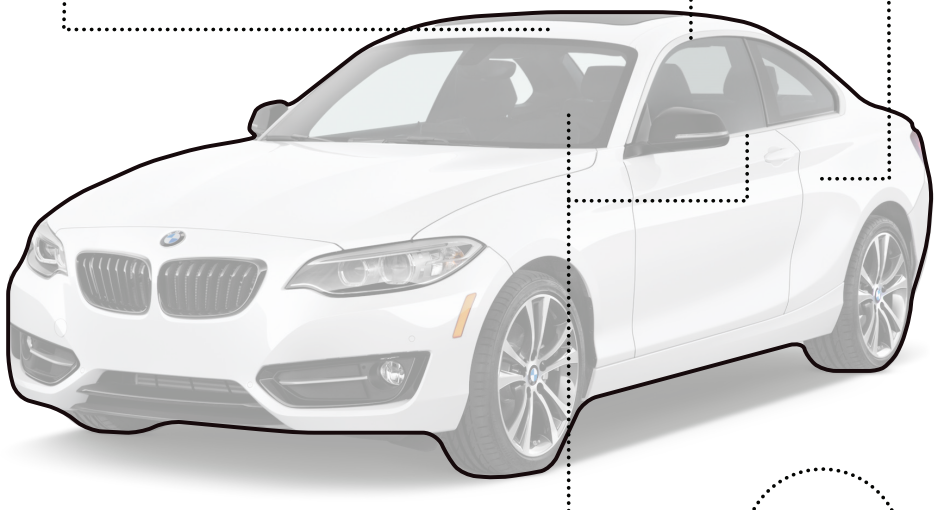
SCHEMATIC

Relative positions of different DRIVERSITY components in a car.

Light sensor with RGB-D camera mounted on top of the car.

Projector located inside the car just above the door attached to the ceiling.

A central computational unit located beneath the rear seats of the car.

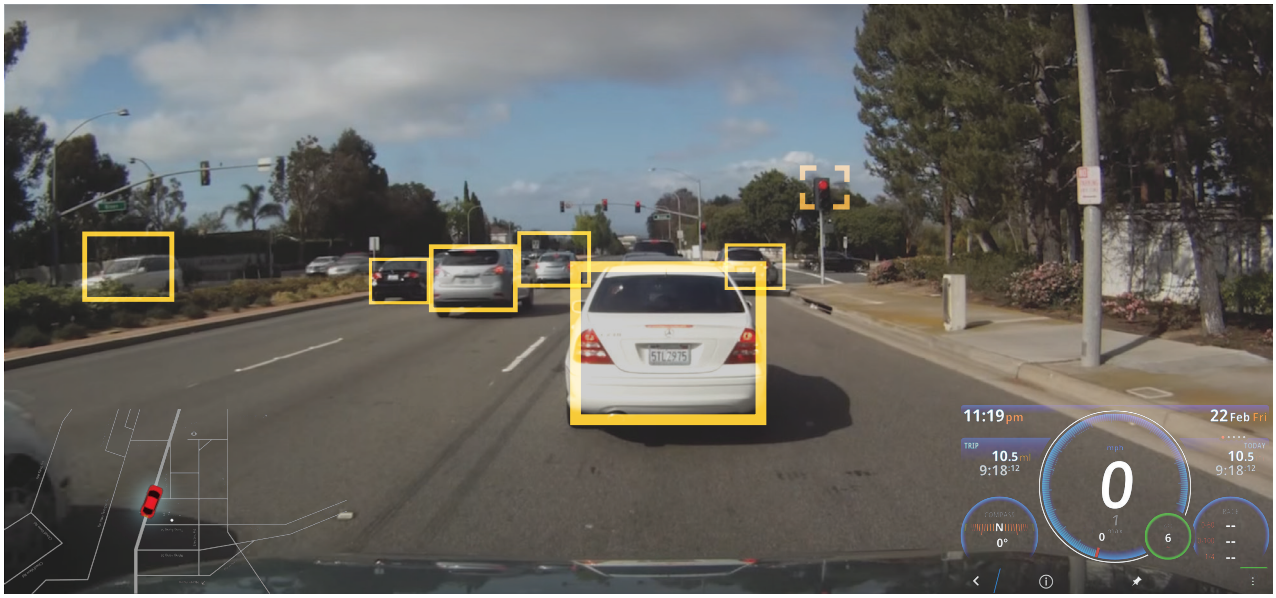


An AR headset for when the user does not want to interact with the windscreen.

Infrared sensor for gesture recognition and eye tracking, placed on top of the dashboard and upper part of door handle inside the car.

DRIVER

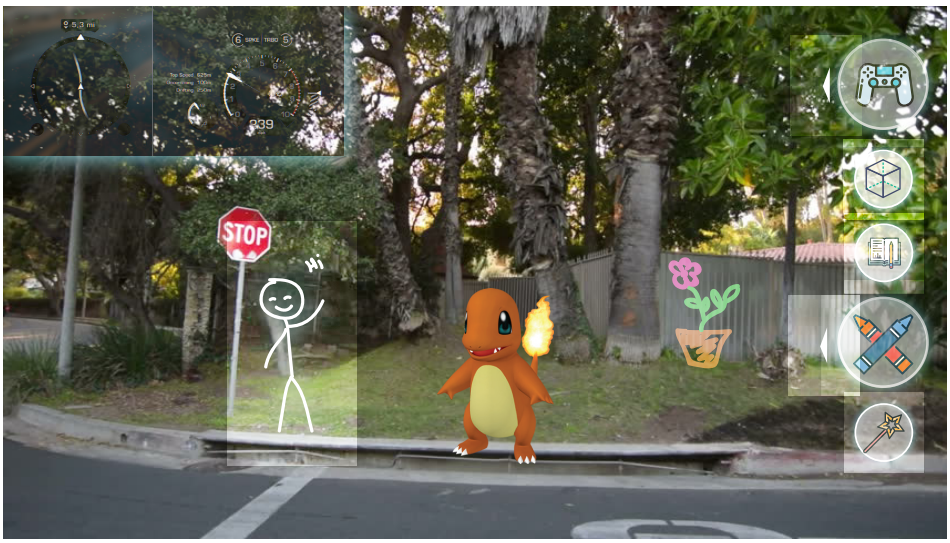
Few usecases of DRIVERSITY setup for a driver.

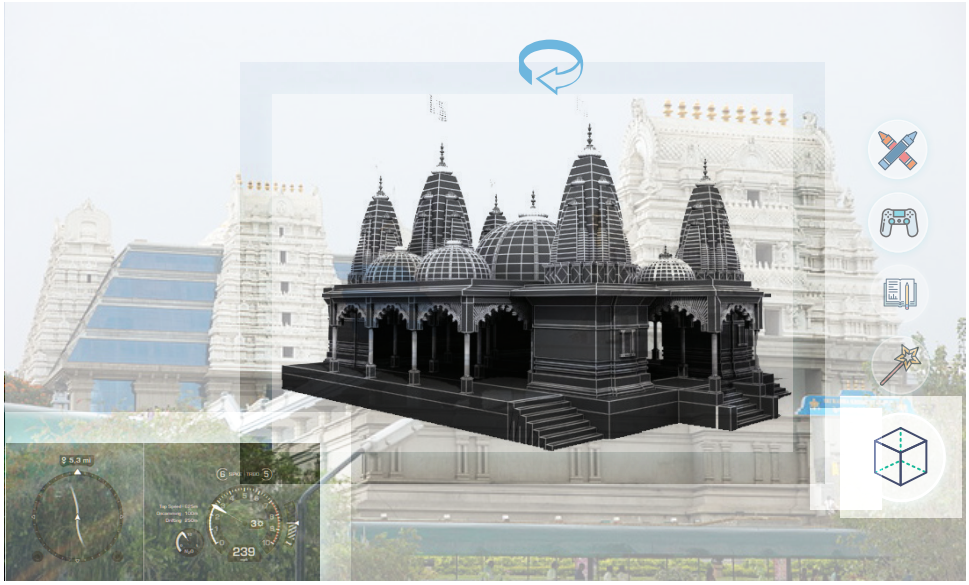


Out of the many diverse possibilities of **DRIVERSITY** for the driver, we've illustrated some of them here. The driver is offered with a whole new ecosystem where he can connect with fellow drivers, but most importantly, avoid the monotony, frustration and boredom caused by routine driving.
The most dreaded situation for a driver is a long traffic jam and in this situation most drivers would be irritated but not anymore. As long as the car is stationery, the driver can switch on to gaming mode and can connect with others around him and around the world. If the route is same for everyday, most probably the driver will be playing with one or more persons around him more frequently making a great connection. Going on a normal empty road, the driver can switch on to simulation mode and can have a car race with a virtual car and compete with the connected friends in attempt to beat their best timings. He/she can also choose any friend / family member and look up what they've been upto in the surroundings. Toggle on your child's profile to see his majestic tree and house on a plain ground that he made a few days back sitting on the rear seat. Move with caution in low visibility conditions, with the RGB-D camera detecting surrounding objects through thermal imagery and providing an approximate idea of the shape, size and distance of any car, pedestrian, object, etc on the road. No need to get distracted trying to follow maps or getting calls. Just a swipe and the driver gets a live gesture controlled map on the windscreen and all the productivity options are also just a toggle away. For elderly, video call your loved ones for any help if needed along with a minimal mode switch giving easy to understand information for not very techno friendly.
So much productivity and fun at the same time for the initially frustrated driver, just that this time he/she forgot to get frustrated!

PASSENGER

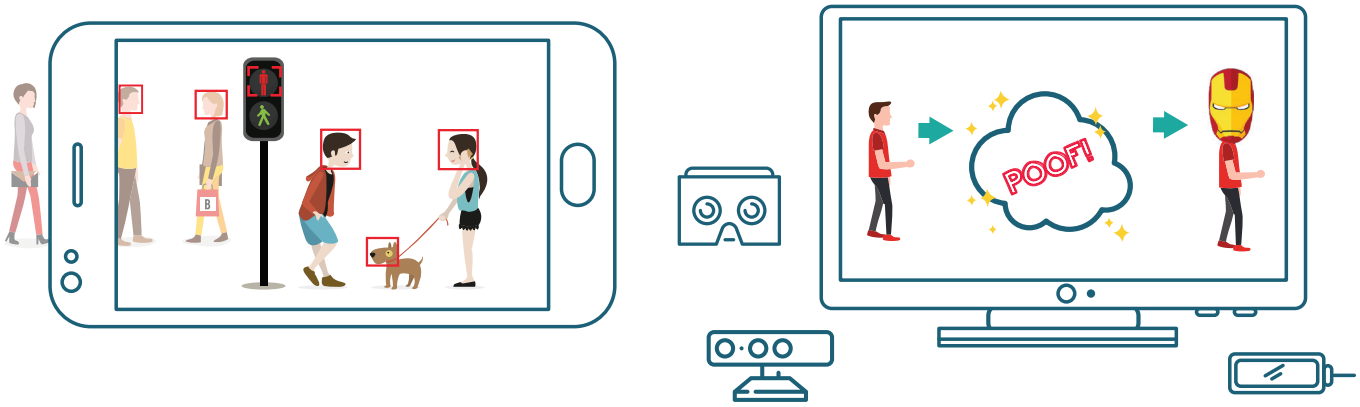
Few usecases of DRIVERSITY setup for passengers in a car.





Passengers in a car have all the freedom to do what they want with **DRIVERSITY**. Switch to drawing and game mode simultaneously and follow your passion of drawing with the real world as the canvas, saving it for friends to see all while catching your favourite pokemon. For knowledge hungry people, click on the surrounding buildings / vehicles / monuments / etc, to get all the relevant information about it and also switch to 3D mode to explore the structure in great depth. Feeling a little too playful, pick up your wand (switch to magic mode) and turn people into fairies or any of your favourite fantasy creatures. Passengers can also wear the headsets and experience the X-Ray vision enabled by the 360 degree RGB-D camera on top of the car. Open and edit presentations, edit documents, shoot virtual arrows on virtual apples on real trees and what not. And all this while you wouldn't have any time to get bored again.

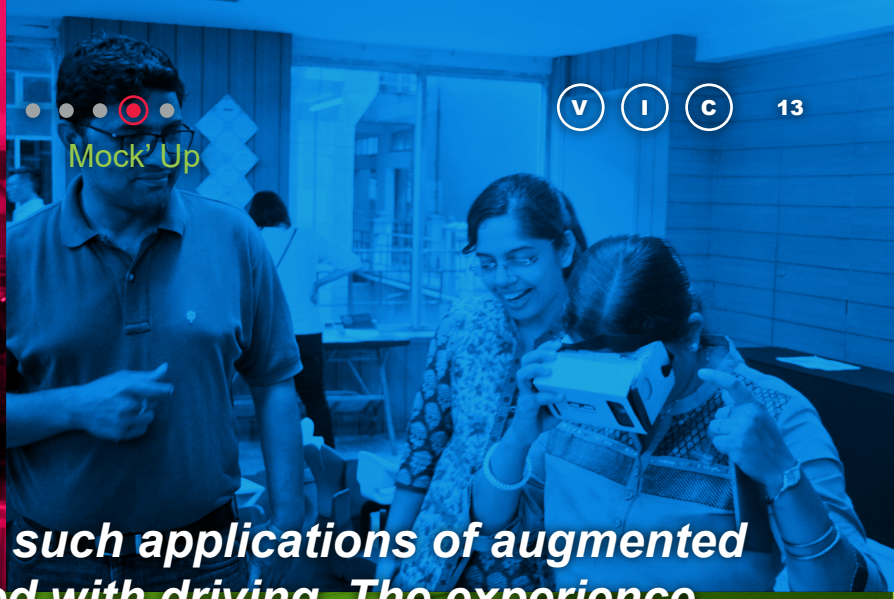
PRESENT YOUR MOCK' UP / PROOF OF CONCEPT



As discussed earlier in 'concepts', Vuforia is the industry leading software developing kit for augmented reality applications. Using the same Vuforia AR engine by QUALCOMM, we developed a simple augmented reality cross platform mobile application that utilizes the advanced computer vision of Vuforia and recognizes and track any given images and basic 3D objects. Along with imagery, we also overlayed static and animated 3d models in the mobile application. This application, on a very basic level, uses the same concept as we have proposed in **DRIVERSITY**. The overall point is to combine virtual and real world. This application is a trivial proof of that. Also we used Microsoft Kinect to recognize a human face and combine a 3D model (in this case an iron man mask) with extended tracking. Also, using the active infrared technology of kinect v2, objects' shape, size and distance can be measured in dark / dimly lit rooms the same principle which will be used to detect vehicles and other physical things on the road in low visibility conditions.

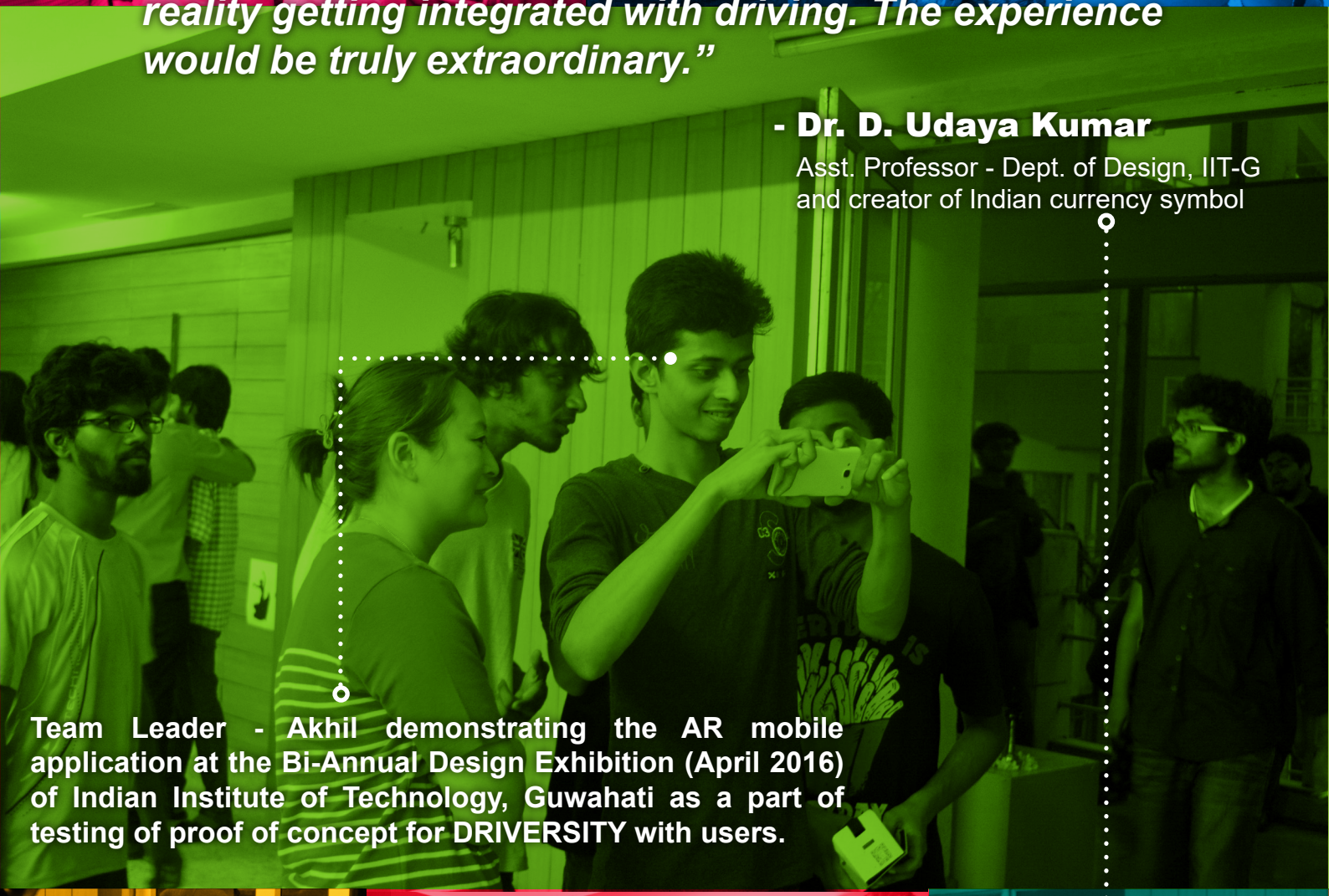
We have also used leap motion sensor for gesture controls and tried calibrating racing game controls to the leap motion and so that steering can be done via gestures of hands. Since gestures are the main medium of interaction, and gamification an important part of our proposal, playing diferent games by using gestures, gives a feel of how it would be like to do so while sitting in a car. Lastly, we switched on stereo mode for our mobile application to be viewed by the AR headset for an immersive experience to simulate the headset experience of **DRIVERSITY**.

We also tested our Augmented Reality mobile application with the headset in the Bi Annual Design Exhibition og IIT Guwahati - 'Prayukti 2016'. We prepared separate installations each with different types of image recognition, tracking and 3D animation. The response received at the exhibition was TRULY overwhelming showing the degree user engagement, AR offers even with a single mobile application. *(Some images from the exhibition are shown on the next page).*



"It'd be amazing to see such applications of augmented reality getting integrated with driving. The experience would be truly extraordinary."

- Dr. D. Udaya Kumar
Asst. Professor - Dept. of Design, IIT-G
and creator of Indian currency symbol



Team Leader - Akhil demonstrating the AR mobile application at the Bi-Annual Design Exhibition (April 2016) of Indian Institute of Technology, Guwahati as a part of testing of proof of concept for DRIVERSITY with users.

BIZ MODEL

Cost estimation and prices of the proposed mock' up.

As mentioned earlier, we propose 2 forms of realization of **DRIVERSITY**. One form is for the upper mid range cars and the second for high end luxury cars. It may very well be possible by 2030 to make this system affordable for every car there is, but according to 2016 it's safe to assume the target markets to be the car owners of upper-mid range to extreme luxury and limited edition cars. For the creamy layer of cars, that is the super high end ones, it's very difficult to estimate the approximate cost involved in the production because of the current unavailability of virtual windscreens in the market. They are believed to be very expensive (as said by Jaguar officials) and if considered in bulk production, the selling price for **DRIVERSITY** setup could be anywhere between $125,000 - $175,000 which is estimated on the basis of fighter jet AR helmets costing a whopping $400,000.
Talking about the upper mid range cars, that is the second **DRIVERSITY** alternative, since virtual windscreens are not in use, price would decrease drastically and estimating cost based on available weak sensors and our mock' up cost, the cheaper version of **DRIVERSITY** would cost around, $15,000- $25,000 on the least. The price includes improved infrared and light sensors, powerful cameras, treated glass/ projection film and most importantly the computational unit.
DRIVERSITY is also not just limited to cars, it can be integrated anywhere from buses and vans to trains as well.

CHALLENGES

Fields to work upon on further development of DRIVERSITY.

As much as we thought and researched about the great benefits of **DRIVERSITY,** a considerable amount of time was given to research about the challenges involved in developing our solution that would eventually enable us to improve and make it better at every stage. Below are some of the key challenges associated with **DRIVERSITY** :

Tracking and Registration : Even with accurate tracking technology, there will inevitably be noise in the system. For example , vibrations from the road surface, etc and the threshold of noise cannot be properly determined upto when the system can accurately track and associate a graphic with the real world counterpart. The challenge is to devise an empirical method to determine the noise level for accurate tracking of objects.

Depth Perception and Estimation : As opposed to 3D stereoscopic displays in VR headsets, having graphics on a windscreen is a monoscopic display where it is difficult for the user to determine the distance between the CGI and the fixed real world objects and research have

shown that users mostly underestimate the distances in the action space. At the same time it is not possible to provide different virtual imagery for both the eyes separately to perceive depth.

Focus DIstance to AR Graphics : Since all the graphics are overlaid on a 2D screen tracking a real worls 3D object, the focal length is determined by the screen and due to the mismatch in focal lengths of the real world objects and virtual imagery, road hazards can be possible in such cases. The challenge is to manipulate the image based on the focal length according to the real world which will require very high computational power continuously.

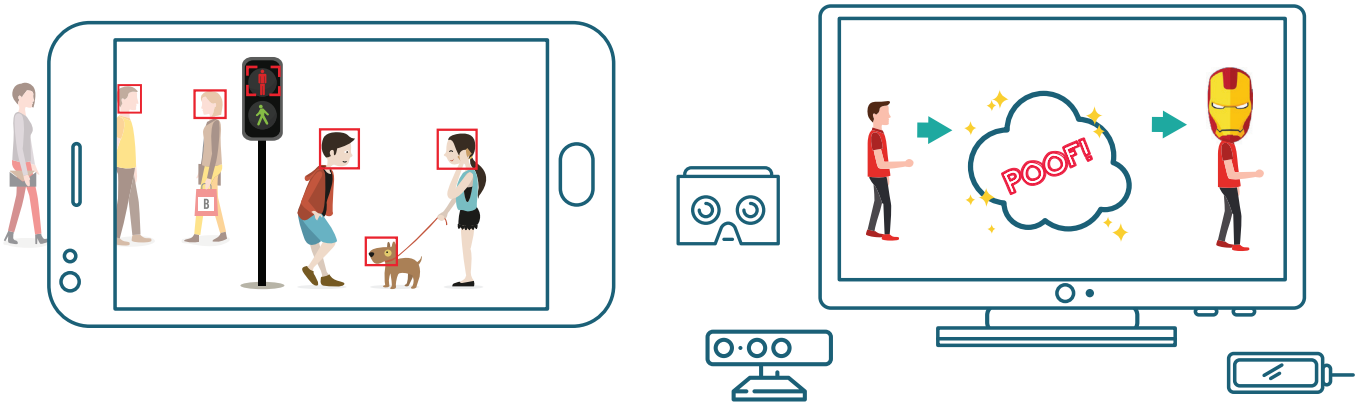
Ergonomics : For the driver, there is no such problem with the ergonomics of the system but for the passengers, one concers prevails. It's evident that a right handed person would be comfortable interacting with the window on the left side of the car. So it'd be difficult for 2 same handed people to use the system equally freely. One solution can be adoption of rotating seats in the car of 2030 as already been done by Mercedes in their Luxury concept car.

Lighting, Backgrounds, and Color Blending : One of the major challenges of optical see-through displays is the problem associated with the combination of digital light and natural light. Washed out colors and blending with the natural surroundings makes it hard for the user to comprehend the informaion on the scree. Moreover, continuous changing of lighting and surrounding environment conditions makes it even harder to see the graphics. One solution is the dynamic screen where background and CGI on the screen adapt to the natural conditions to maintain a consistent contrast and improved visuals. Advanced algorithms are required for the same.

Clutter and Occlusion : Lot of digital information at once on the windscreen could be overwhelming for the driver and as a result, the goal of reducing the distraction would be defeated. It's possible that the government would define the standard information display quantity on a virtual windscren to prevent any unwanted road hazards in 2030. One more solution is dynamic information allocation on a windscreen based on what lies ahead of the road and optimizing the location of information such that it does not obstruct the view of the driver. One such technology has been patented by Toyota in early 2016.

Internet dependence : Since most of the functionalities of **DRIVERSITY** are internet dependent, the obvious challenge arises when there is no network coverage around. At this time this may seem a considerable drawback but by 2030, most of the areas would be wirelessly connected via internet keeping in mind the rapid growth of such measures (like providing internet to remote areas via hot air balloon) by tech giants like Google and Facebook.

IF YOU BELONG TO THE TOP 4 FINALISTS



If we belong to the top 4 finalists, we plan to present a full information architecture and high fidelity user interface for **DRIVERSITY** with full interactivity on a touch device. We'll talk about the vast possibilities of AR in automotive industry and the role of the same in user engagement. Also we would be demonstrating a transparent glass screen covered with rear projection film to give an idea of what actually interacting with teansparent screen looks like with the help of a projector, projecting the UI on the glass panel. All the other components (kinect, leap motion, projector, headset) would be used and the result will be projected on the glass.

Materials requested from Valeo : A1 (594 x 841 mm) size transparent glass, a big monitor for presentation.

Mock' up transportation : We'd bring a projector, 1 kinect sensor, 2 laptops, 2 AR headset, 1 leap motion sensor and one 600 x 900 mm rear projection film roll.