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Demo

VirtualCar: Virtual Mirroring of IoT-Enabled Avacars in AR, VR and Desktop Applications

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Abstract

This demo features a virtual 3D car model based off a vehicle's data duplicate, an IoT-enabled Avacar. There are three embodiments including a desktop application (VirtualCar), Augmented Reality (VirtualCarAR), and Virtual Reality (VirtualCarVR). The Avacar gets information from an external API serving information from a real or representative simulated vehicle, mirroring the sensors present in modern On-Board Diagnostic systems and the location data provided by a mobile device's GPS. In each application, the Avacar appears at specific locations around the world, using the Unity Game Engine to virtually mirror the behavior of the actual or simulated vehicle in real-time.

CCS Concepts

• ***Human-centered computing*** → Mixed / augmented reality; Virtual Reality • ***Applied Computing methodologies*** → Computer games; • ***Hardware*** → Sensors and actuators;

1. Description and Purpose of Demonstration

The purpose of the presented research is to develop a system for mirroring the real or simulated data of a particular vehicle within a virtual environment. Vehicle data may be provided by means of an external file, or a secure API with access to raw vehicle sensor data or simulated sensor data. The virtual environments are built using desktop, Augmented Reality, or Virtual Reality (AR-VR) concepts and based upon the Unity3D framework.

To optimize for presentation purposes and ensure the availability of real-time data during the demonstration window, this initial revision uses sensor data stored in a prerecorded file on a remote server. This JSON file [AECL17] is a public sample and not connected to a real vehicle. Its attributes can be edited via external tools (FileZilla), and changes will propagate to the visualization. Applying authentication methods (oAuth2.0) to our sample, we design a secure end-to-end Internet of Things model implementation [SKS17] for twinning automobiles. At the same time, we created a desktop Application, an Augmented and a Virtual Reality application where users can visualize realtime changes in vehicle speed, engine speed, and location (location changes require the use of Unity3D's editor mode and a software reload) to fetch the new 3D environment objects.

```
{
  "id": "f61ba3d5-a68e-43eb-a731-0db871b4d3a3",
  "user": {
    "id": "U_ffd955ba63db5c25",
  },
  "type": "notification:speeding",
  "created_at": "2015-04-12T17:45:18.123Z",
  "time_zone": "America/Los_Angeles",
  "lat": 48.85564,
  "lon": 2.297013,
  "accuracy_m": 10,
  "created_at": "2015-04-12T17:45:01.123Z",
  "vehicle": {
    "id": "C_507d6f1bd6d9b855",
  },
  "device" : {
    "id": "021ac91c826b12eca99e685c"
  },
  "velocity_kph": 100,
  "RPM": 4000
}
```

Figure 1: *Sample JSON file showing operation parameters for a representative vehicle.*

This application is grounded in the need for improved vehicle data visualization tools. For example, the applications may be used to monitor teenaged drivers, or remotely, for insurance agencies to supervise consenting drivers in order to reduce premiums. It is a first-of-its-kind graphical representation linked to connected cars, with the three applications reflecting contributions to the state of the art in data-informed vehicle visualizations. The underlying archi-

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tecture has the potential to support applications improving transportation safety, efficiency, and comfort while building consumer trust in connected cars.

2. Technology and Techniques

The demo consists of three parts, all of which are developed using the Unity3D game engine. To ensure performance, low-poly location based terrain is generated by Unity's Wrld plugin at startup. Changing the latitude and longitude within Unity's Editor mode passes new parameters to the virtual vehicle and generates new terrain topologies each time simulation restarts.

The sensor data shown on the upcoming applications' dashboard gauge overlays comes from the JSON attributes "velocity_kph" and "RPM" (Figure 1). When these attributes are changed within the file, the gauge needles move to reflect the changes in real-time. This occurs as part of an on-frame update function wherein Unity updates its environment. The data are scraped using a C# script which can be modified to access both public and private (embedded authorization token) APIs [TGPM*13].

2.1 Desktop Application (VirtualCar.exe)

The Desktop Application uses a two-camera model, with the first camera providing a 3rd person "birds eye" view of the Avacar. The second camera is inset like a mini-map, and provides a view from the virtual driver's seat. This provides a view of the Avacar's dashboard, and is representative of what a desktop-based "teen tracker" application might look like.

Figure 2: *Desktop Application featuring a two-camera view. The Avacar is viewed from the 3rd person atop a procedurally-generated map of Cambridge, MA, USA. The minimap shows the driver's view of the dashboard, with real-time gauge updates indicating vehicle and engine speed.*

2.2 Augmented Reality (VirtualCarAR.apk)

Augmented Reality applications can be both markerless [PLRS*17] or image targeted. Our AR implementation uses an image targeted model based upon the cross-platform Vuforia plugin. This plugin uses a database of images and for this demo presentation was trained to follow a single marker image (see tracking image, Figure 2). When the device camera tracks this image, a three-camera view of the map, speedometer, and tachometer (Figure 3) automatically appears with the map orientation varying along with the orientation of the marker image.

Figure 3: *This is VirtualCar's Augmented Reality tracking image. It attains a five-star rating from Vuforia's WebPlatform.*

Figure 4: *The Augmented Reality Application features a three-camera view; including a 3rd person view of a procedurally-generated map (Cambridge, MA, USA) and dashboard gauge overlays. The tighter view of the map reduces the number of polygons necessary to render.*

2.3 Virtual Reality (VirtualCarVR.apk)

Virtual Reality is a new and immersive technology that offers advantages to the automotive industry [LSW16]. In our case, the VR implementation uses Google Cardboard in Unity. In this demo, the user sits in the driver's seat and views the virtual dashboard along with outside low poly buildings visible through the windshield. As with the desktop and AR applications, these buildings are also procedurally-generated.

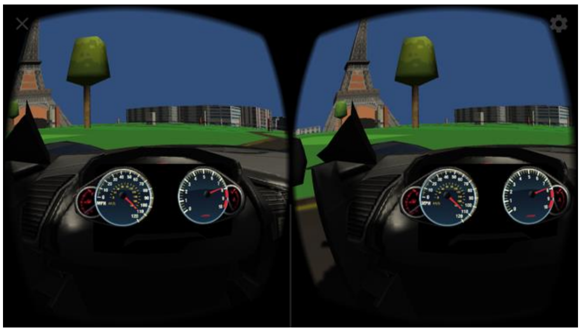

Figure 5: *Virtual Reality Application featuring two-camera view. The driver's 1st-person view is located within the Avacar and shows the procedurally created map (Paris, FR). At the same time, the user can see the real time indications of Speed and RPM.*

3. Future updates

Future improvements will include additional gauges and indicators. The demonstration will also be connected to a live API, like CloudThink [WSM*15]. Once these applications are robust, additional indicators will be added to highlight potential problems based upon the real-time vehicle data, for example identifying engine misfires based on acoustic analysis [SKE*16].

4. References

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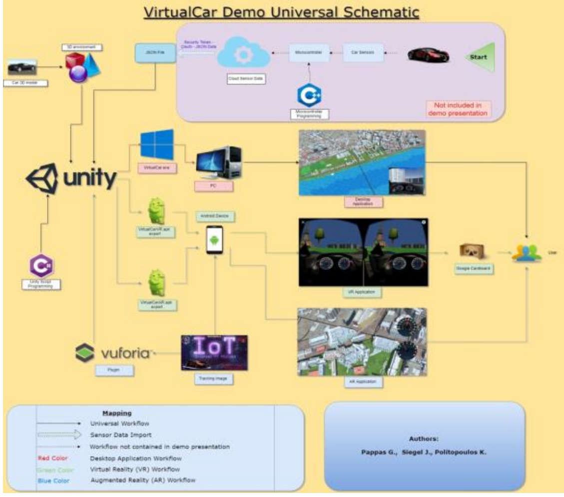

Figure 6: *VirtualCar Demo Universal Schematic showcases the workflow of all the parts of the demo in a single diagram.*