**Initial background**

Virtual Reality is being used across many fields to provide experiences that may not be otherwise possible, aid patients in physical or psychological recovery, train military and healthcare personnel, and to help users or developers test products, among other applications.

* **What is the application area, and what does VR offer to this area that other approaches do not?**

Product testing is one of the popular applications, companies being able to test prototypes of designs, layouts and specifications using Virtual Reality. Doing so allows them to create and try out blueprints for products without any risks that testing physical prototypes may involve – Ethics surrounding human and/or animal testing, cost and time required for materials and production and any physical equipment (save for Virtual Reality setups!).

One of the strongest points is that products could be set up with multiple variables, and altered in real-time during the testing, decreasing the time required to test all possible aspects, generally lowering costs and making a more streamlined testing profile also.

Consumers can also test products before they buy them, including cars, clothing (Normally in the case of Augmented Reality), furniture and holidays, without needing to leave their home. This could be incorporated into current online shopping’s features to further increase its popularity, or let the user test the product more vigorously without the manufacturer having to worry about damage if using an in-store system.

* **What research (VR or non-VR) or development is currently being done in this area? (This should be extensive and up-to-date)**

Audi (Ref. 2, Ref. 6) are developing a system which incorporates virtual reality into showrooms, to allow customers to view parts in a more interactive way before purchasing, as well as take virtual test-drives of their cars. This allows for them to use less space in more urban showrooms to display more of their available range, and customers can take a virtual test-drive at their leisure without even entering the showroom, using Google Cardboard, although they are also partnered with Samsung using the Samsung Gear VR.

Volvo have also developed a Google cardboard (Ref. 3, Ref. 4, Ref. 7) application allowing users to experience a test drive of their XC90 car, offering the product to any consumer with a cardboard-compatible smartphone online at no charge, making the application a far more interactive advertisement to consumers.

Fiat (Ref. 11) are using the Oculus Rift at events and Google Cardboard for online consumers to experience a more “Augmented” experience of their 500X car – Mixing live footage and CGI to create a more ‘unusual’ test-drive of the car – Allowing consumers to enjoy an experience a test-drive that would be otherwise impossible in a physical test.

Lexus (Ref. 12) are using the Oculus Rift along with an actual steering column from the car allow users to perform a complete test-drive themselves of the RC F model, without having to leave the showroom.

Ford (Ref. 14) have made an augmented reality app which allows consumers to view the latest Ford Mustang model in a location of their choice, also allowing customisation options of the car to their liking, in order to promote the vehicle.  
Ford as manufacturers have also been using virtual reality headsets since 1999 (Ref. 15), using their own technology (recently working with companies such as Oculus, HTC, Samsung and Microsoft) in order to create and test virtual models of cars and car parts, allowing engineers to discover issues with design earlier in processes, work with more possible configurations, and begin development of new technologies that may have been too risky to start physically.

Atticus Digital (Ref. 8) work with existing 360-degree technologies, HMD devices and motion-capturing hardware such as Oculus Rift, Playstation Move and Microsoft Kinect to create VR experiences for clients to use on market, including IBM, EDF Energy, MIMI Engineering and MBA.

Haptic product creation/development (Ref. 9) has been developed for manufacturers to be able to test materials during creation – softness, etc. Networking has also been incorporated to allow for multiple users to work on the same product at once.

Companies such as Clear VR (Ref.10) offer market testing for a product – For example, placing products in a retail environment, mainly using display devices such as the Oculus Rift. This can allow manufacturers to test a product’s marketability without the production costs, travel costs or potential risks involved in performing a full test in a retail store, testing against samples of consumers before a physical product or prototype is made. This can also the product to be tested in multiple locations at once as each user is “moved” to the virtual environment for testing.

* **What technology (hardware and software) is being used in this area, and why are these choices made?**

Manufacturers will typically have a full CAVE system implemented to test products, as these can provide the most immersive experience with which to envision virtual scenes or products for testing. These could incorporate projected images on walls, surrounding speaker (sound) systems and racking sensors, although many will now also incorporate a head-mounted display (HMD) and omit the projectors/screens, as this can provide similar or better immersion at a lower cost.

Haptic systems are also used, such as “data gloves”, which can provide feedback through vibration to the user if they are in contact with objects, allowing the user to better feel their way through the virtual environment. This can also allow manufacturers to test materials used in development.

When trying products consumers will most likely be using a HMD device, especially cheaper devices such as Google Cardboard (with a smartphone) in a home-based environment, the low cost of the device offering far greater accessibility and still offering a strong level of immersion.

Headphones can also be used as a low-cost way of immersing the user with sound along with a HMD.

* **What are the opportunities, limitations and risk in this area?**

Manufacturers will have expensive upfront costs when developing a CAVE system, as high-end parts will be required to minimise possible eye-strain and inaccuracies in input/feedback with the user.

Consumers as of now may not be able to afford possible features such as motion capture, which may break immersion as the user takes part in a more passive environment when viewing a product.

More immersive virtual environments can cause issue in a real environment where obstacles are less controlled, could cause tripping and minor injuries.

* **What special considerations might there be (use of audio or sensory feedback, whether stereoscopic projection is important, whether the location or user-group constrains the application design or deployment)**

Audio may be of use in consumer and manufacturer testing may depend on the product – Cars for example will benefit from audio usage as engine noise can be a contributing factor to satisfaction and experience, whereas clothing would provide no benefit.

Sensory feedback would more be suited for development, as the costs involved with haptic technology makes the majority of consumer use impossible, while it can aid manufacturers by offering tests of the current materials used on the product.

Stereoscopic projection in technologies such as Google cardboard makes it easily accessible, allowing for consumers to make use of it in the majority of applications.

While manufacturers are able to use large deployments and intensive applications due to generally larger budgets and spaces to work with, consumer-based applications limit the hardware and specifications that can be used to reach as large an audience as possible, mainly working with mobile phone/cardboard applications.

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