A Proposal for Augmented Situated Visualization Towards EMC Testing

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Abstract

In EMC testing, 3D electromagnetic field data often needs to be visually analysed by an expert in order to detect product defects or unwanted interference between multiple devices. In this sense, the present work proposes the use of data visualization techniques allied to an Augmented Reality user interface to provide information that helps professionals to analyse the same data, however spatially situated where it was first measured.

Apart from visualizing it, users may also interact with the data to narrow down their search by switching the attributes being displayed, combining them together, applying filters or changing the formatting in which data is presented. The approaches being proposed in this work will ultimately be tested against each other in comparable 2D and 3D interactive visualizations of the same data in a series of usability assessments with users to validate the solutions. The goal is to ultimately expose whether AR can help users to make more accurate decisions, particularly in EMC related tasks.

Index Terms: Human-centered computing—Visualization—Visualization techniques—Treemaps; Human-centered computing—Visualization—Visualization design and evaluation methods

1 Introduction

In electrical engineering, it is known that activity of electronic and electrical devices can be highly affected by the frequency components of electromagnetic waves emitted from external sources, such as natural lightning, fluorescent lights, digital computers and even other similar devices [9]. Radio receivers, for instance, intercept these waves, amplify them and extract the information encoded in them. Any electromagnetic interference (EMI) intercepted by the receiver will cause the transmission to be either disrupted or misinterpreted, as exposed in Fig. 2. According to Paul, Electromagnetic Compatibility (EMC) is the study concerned with the design of electronic systems such that interference from or to that system will be minimized, in order not to affect any of its surroundings. Still according to Paul, a system can be considered electromagnetically compatible with its environment if it satisfies three criteria:

1. It does not cause interference with other systems.
2. It is not susceptible to emissions from other systems.
3. It does not cause interference with itself.

EMC testing measures the amount of EMI both radiated and conducted by electronic devices. This kind of procedure ensures whether or not the criteria mentioned above are being obeyed. In his book, [6] exposes that it advantageous to submit even particular hardware components to tests during the design process of such equipment. Frequently, these criteria need to be visually observed by an expert, looking at 3D spatial data of the electromagnetic field being analysed.

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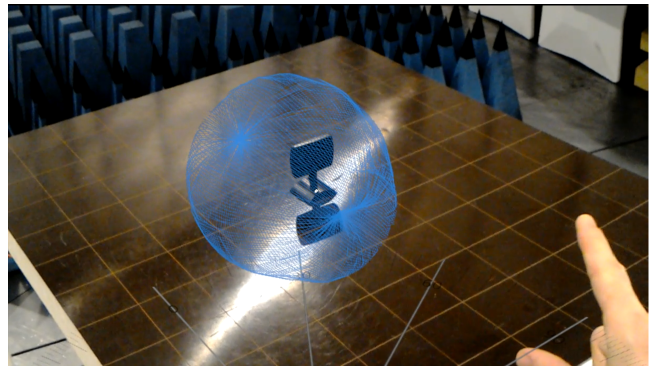

Figure 1: User interacting with an AR rendering of an electromagnetic field

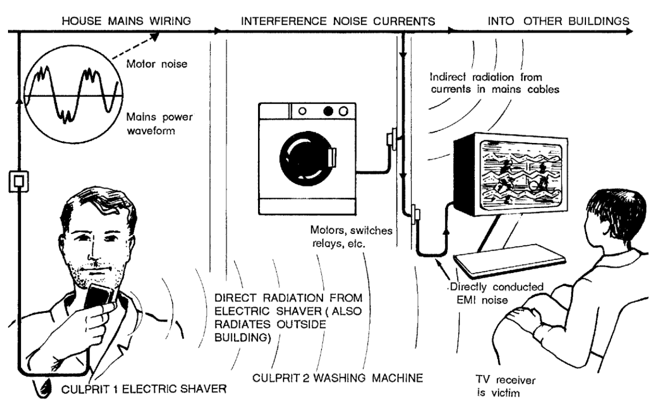

Figure 2: Illustration of a simple EMI problem [6].

It is possible to redress this sort of problem through a data visualization that presents visual and interactive information situated in the actual space they are relevant in. Augmented Reality (AR) arguably has the potential of significantly increasing the possibilities of problem assessment by making data spatially context-aware and reducing user effort [12]. Tasks such as these that require decision-making, however simple they are, may be optimized with this sort of visualization [8], either by reducing the time, mental effort or previous knowledge required to perform such tasks. Thus, decision-making, following Balleine's definition of being a choice between multiple courses of action [1], could be facilitated and user comfort elevated. Hereupon, this work intends to review, design and suggest

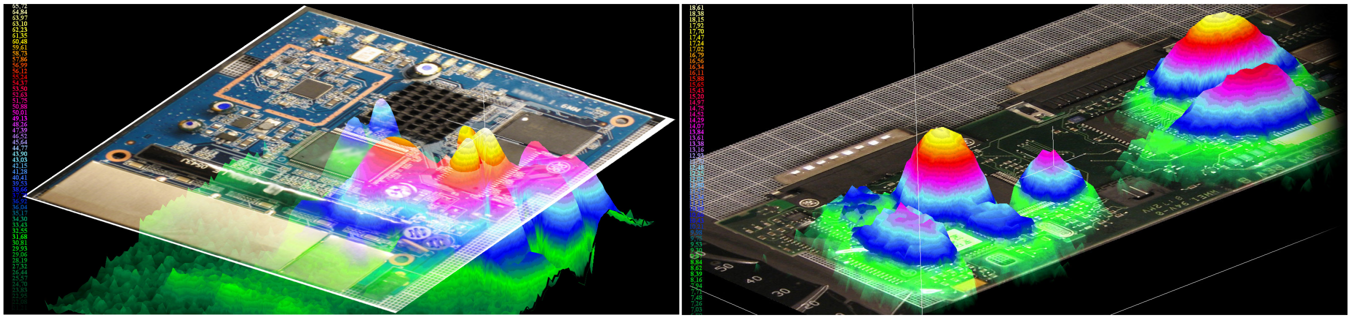

Figure 3: Scanned data visualization of two circuit boards, superimposed to the actual hardware components submitted to testing.

the use of Information Visualization techniques, especially Situated Visualization (SV) [12], as well as novel interaction methods particularly aimed at this context. Alongside an AR Optical See-Through Head Mounted Display (HMD) to provide information regarding the user vicinity, SV aids users in familiarizing themselves with the data without having to exhaustively explore it or mentally translate it.

2 Related Work

In a 2018 study, Sato et al. [11] developed a method to display the intensity of a three dimensional electromagnetic field measured using a tablet screen by combining simple devices. Using AR markers to position it according to the viewpoint of the observer, it was possible to visualize the 3D distribution of the field by holding the device over the measured object. The data displayed in the work, however, is quite discrete, failing to expose the continuity of the 3D fields. Its method of measuring the data was also deemed not very precise.

In a related work of the same year, Isrie et al. [5] described a data acquisition system, which displayed data from a power sensor and its GPS location in a heads up display (HUD). This allowed users to walk and see the measured data in AR without the need to look down at a different screen and missing important real-time data of the measured electric field strength. Although arguably using AR, the data in their work is purely 2D and fixed in a HUD display, not at all being situated in the surrounding area of the user.

Among the most relevant works in the area, a 2019 study by Rioult et al. [10] demonstrated an EMC scanning system aimed at facilitating readings in confined and remote environments via a fast and compact device. Using a smartphone coupled to EMC sensors, along with AR technologies, the device is capable of measuring electromagnetic fields as well as presenting them situated *in loco*. The work focuses solely on relatively small scale situations, arguably not being on par with state-of-the-art EMC scanning precision. It also requires users to hold the scanning device, limiting their interaction possibilities.

As to address the disadvantages mentioned, the current work intends on exposing EMC data in a more continuous and precise manner, preserving the 3D topology of fields, as well as spatially situating them where they were measured, in relation to the device being analysed, supporting the Situated Visualization paradigm. In recent works, different researchers compared the efficiency of data perception and analysis in SV against traditional 2D manual and interactive interfaces in different applications. These works exposed a few advantages in tasks performed in the AR approach, including gains in accuracy [3], lower time taken for tasks [2] and lower cognitive effort levels [4].

Much like in these works, our data will be displayed in an AR HMD with spatial mapping capabilities, allowing for a more realistic and precise location of virtual objects, as well as presenting them in an egocentric view, freeing the user's hands to interact with the data. The work will focus both on readings of small device emission fields (*desk-scale*), as well as bigger ones (*room-scale*).

3 Methodology

In order to expose the adaptability of SV and the proposed methods, a few use case scenarios will be designed and tested. These are meant to be applications of the visualization methods in real commercial, academic or day-to-day problems. Specifically aimed at EMC testing, the following two preliminary use cases are proposed.

3.1 Desk-scale EMC visualization

Nowadays, the testing of small components is usually done with EMC scanners, such as the Detectus RSE 642[1], which is able to measure the EMI in a high range of frequencies. Since the spectrum analysis of this sort of scanner is done with a near field probe attached to a X-Y-Z robot, it is able to render a three-dimensional graphical visualization of the data read, much like can be seen in Fig. 3. This kind of visualization enables experts to detect potential emission problems before they become integrated into a final product, also exposing what component is causing it, based on the data position.

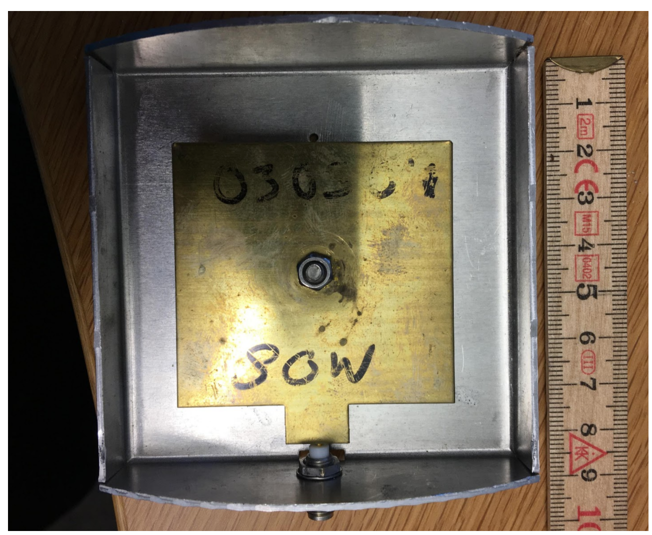

Figure 4: Sample antenna analysed in the chamber.

We propose to implement a framework which will provide users with an Augmented Reality visualization of EMC scanned data, superimposing the actual scanned components or devices, much like

[1] http://www.detectus.se/rse-series.html

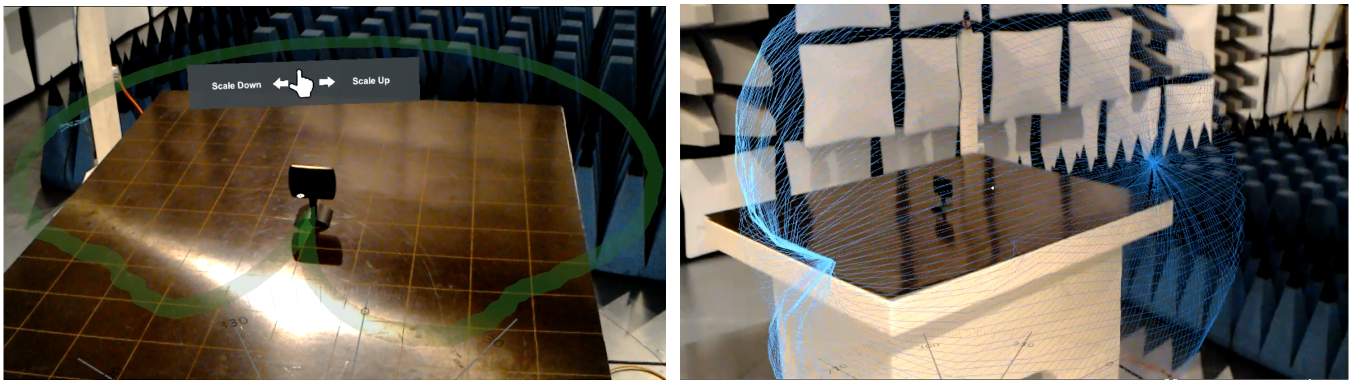

Figure 5: SV of two sets of EMC data, superimposed to the actual antenna submitted to testing. Left - 2D data, a planar segment of the field. Right - 3D full field data.

the mock-ups available in Fig. 3. Since the scanner is able to generate field plots in a wide band span, it will be possible to compare visualizations of multiple frequencies, either by overlapping them or interacting with the system to change the current one. Another intention is to render the EMC data from multiple components at the same time, allowing users to understand how they will interfere with each other once they are placed in the same system. For this purpose, we intend on using the Vuforia Engine[2], which is capable of using 3D scans of real objects as markers, making it possible for the application to track the actual devices in real time.

3.2 Room-scale EMC visualization

Regarding larger devices in their integrity, entire rooms may be required for testing. In conducting this sort of experiment, it is recommended to isolate the test space from the outside electromagnetic environment. According to [6], it is undesirable (and in some cases illegal) to radiate high field strengths across whole bands of frequencies when conducting radiated susceptibility testing. For this purpose, the use of screened chambers became widespread, usually built as Faraday cages and lined with absorbing material inside, making them anechoic - i.e. rooms without any reflection of either sound or electromagnetic waves. Inside the room, a large, however a simple conducting structure, antenna is used to detect the electromagnetic emissions of the devices being tested. Additionally, circular platforms are used to rotate the devices during testing, as to capture a 360 degree view.

Having access to one of these anechoic chambers, fully equipped for radiated emissions and immunity testing, our proposal is to render these room-scale EMC readings in 3D, in order to build an AR situated visualization of the test results. Much like the aforementioned proposal, however in a larger scale, these readings are meant for users to detect any EMI that may cause the equipment to malfunction or affect other systems. The main advantage of such an application is to spatially expose exactly where the interference is being propagated from and into what other components. In a situated view, it will be possible to perceive the influence of multiple devices on each other *in loco*, either inside the anechoic chamber or anywhere else these devices will be located at.

4 Preliminary Results

In a preliminary attempt to demonstrate the proposal, an application prototype was developed where the real 2D (planar) and 3D EMC data read from a sample antenna (seen in Fig. 4) emission was parsed, converted from spherical to cartesian coordinates and rendered situated inside the anechoic chamber environment. For this, the physical room was scanned into a three-dimensional mesh, with its points in space being used as anchors for the data to be placed upon. Then, by loading this environment, with the data already being displayed in the right place according to the virtual mesh of the chamber, into an AR HMD with spatial tracking capabilities, the mesh can be matched with the real architecture of the area the user is located at. For the current project, the Microsoft HoloLens (1st generation)[3] was used both to scan the room and to display the data to users.

As can be seen in Fig. 5, the virtual field is superimposed in the real environment the user is seeing. This arguably allows for a less cognitive demanding analysis of the data, since the proposed egocentric view of the surroundings does not require the mental translation from a 2D screen into the 3D surrounding space necessary in the allocentric task that is performed nowadays in the EMC industry. This argument, however, will be put into test in a future user experiment, where decision-making tasks will be performed and their performances evaluated.

In a quick demonstration made to three experts in the EMC testing area, feedback was outright positive. Users commended the visualization presented as being highly useful for analysing real data, even at a commercial level. As to work in a spiral model of software development, this demonstration served as a first prototype in order to verify and validate the concept, as well as using the feedback from the community as to understand their needs and fulfill those in upcoming projects.

5 Future Work

As to properly evaluate the use of SV in the EMC field, formal user tests are required. The next step in the current project is to test the proposed visualizations with experts with EMC backgrounds. Inspired by User Testing guidelines by Nielsen [7], a test with five expert users will be performed, as to look for and address any problems with the interaction and visualization, as well as suggest different ways in which this paradigm could be explored. The test is to be held inside the anechoic chamber, with a set of interference avoidance tasks, where subjects will analyze the EMI data between two different antennas and move them around as to get an optimal placement, minimizing interference.

6 Conclusion

This work presented a proposal for an augmented situated visualization method for aiding decision-making in an EMC testing context.

[2]https://developer.vuforia.com/

[3]https://docs.microsoft.com/en-us/hololens/hololens1-hardware

The use case application is intended for helping expert users to analyse electromagnetic fields and EMC data in general. Using an AR HMD, users are able to visualize the spatial data read by high level industry standard equipment, such as an EMC scanner and an antenna inside an anechoic chamber.

This approach presents a highly compelling visualization for the state-of-the-art both in augmented reality and EMC testing, since new AR platforms are expected to emerge with less intrusive and cumbersome devices, supplying users with a more detailed and thorough field of view. Furthermore, this work will proceed with a comparison in user performance of tasks common to the EMC area, with the intention of assessing whether and how SV may offer advantages to this sort of activity.

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