gARphics – Data Visualization using Augmented Reality

Ratnesh Chaturvedi[1*], Nitya Darshanil[1*], Yash Kumar Gandhi[1], Neelak Ghosh[1], Shantanu Gupta[1] and Archit Sen Gupta[1]
*[1]Narsee Monjee Institute of Management Studies - [**NMIMS** Deemed to be University]*
V. L, Pherozeshah Mehta Rd, Vile Parle, Mumbai, Maharashtra 400056
**Contact: ratnesh.chaturvedi@nmims.edu, nitya.darshanil24@nmims.edu.in*

Abstract—
Big and open data constitute a burgeoning field of study within the current context. The advancement of innovation is, in turn, expanding its degree of interactivity. This paper explores the concept of Augmented Reality (AR) for Data Visualization utilizing an app called gARphics. An experiment was performed to compare an AR interface to a desktop-based interface. The result appeared that clients had a less demanding time noticing exceptions and designs since they were able to approach or back away from the visualization. It moreover provided helpful access to a huge quantum of data and advertised a view from different points. Exploring through the data became smooth with the assistance of unmistakable and verbal interaction. Visualizing data in 3D allows clients to reveal patterns and designs that will not be promptly unmistakable with 2D visualizations.

***Keywords*— Augmented Reality, gARphics, Data Visualization, Immersive Technology, Tangible Interface, Interaction, 3-Dimensional Space**

I. INTRODUCTION

Today's data society has been configured as a complex situation in which data utilization and data proliferate. Institutions and organizations, on the one hand, have an expanding propensity to leave information open. At the same time, disciplines related to data access and administration emerge, such as data science, data mining, big data, or deep learning. Increased Reality opens space obstructions and change the way we analyse data. People live in and explore through a 3D world. Collaboration with AR objects may be a common and natural way to understand and learn. Immersive visualizations enable us to see numerous dimensions within the data at the same time. It can be troublesome to see a part of factors on a computer screen but it's simple in AR. With Immersive Information, the client can effortlessly alter factors in a visualization to change the data they're seeing. gARphics is an augmented reality visualization instrument that permits information researchers and business officials to rapidly investigate and understand data. Distinctive from the past advances which utilized headsets, the modern app permits our clients visualize their information in increased reality utilizing Android Smartphones. We are enabling the user to visualize complex data in a basic way. Augmented Reality (AR) ordinarily includes the overlay of virtual imagery on the genuine world. In this paper we investigate how AR interfacing can be utilized to see complex datasets. We believe that AR techniques may well be useful for a few reasons, including:

- Increased comprehension of complex datasets
- An expansive virtual display of visualization in AR
- Easier time taking note exceptions and patterns

Data Visualization interfaces provide a stage for building valuable applications that have progressed data comprehension, but the address remains: does this impact exchange to Augmented Reality? We hypothesize that the same increment in comprehension for diverse charts and plots happens for Augmented Reality data displays as for screen-based 3D interfacing.

To test this theory, we conducted an try in which we were concerned with comparing a 2D on-screen viewing condition, to 3D on-screen and Expanded Reality seeing conditions. Members were appeared arbitrarily produced charts, at diverse levels of complexity, and inquired questions related to the visualization of exceptions. This study made a difference us decide the appropriateness of AR for data visualization. Another advantage of the use of AR for data analysis, is that the application effortlessly coordinates with day-to-day tools that are as of now a portion of users' workflow – like a smartphone. We imagine two fundamental use cases for our application –

- Data Exploration
- Presentation

In spite of the fact that a few bunches have used AR interfacing for scientific and mathematical visualization, as however there have been no user studies conducted comparing performance with these interfacing to screen-based systems.

If our research appears that AR interfacing perform as well, or better than screen-based interfacing on chart investigation errands at that point this may have noteworthy implications for future AR visualisation interfaces.

II. MARKET ANALYSIS

Some time recently building the project, it was essential to know the current whereabouts of the data visualization situation. There are numerous tools present within the market, but the issues that clients are confronting and their proposals with respect to them, we carried out a market survey that tended to the current needs of users concerning data visualization choices accessible.

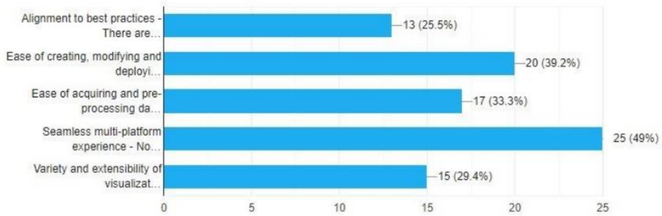


Figure 1: *AR attributes that can make data visualization a better experience*

As seen in figure 1, 49% of the clients overviewed said that a consistent and multi-platform involvement would make the method a parcel superior. 33.3% populace concurred that the ease of securing and pre-processing the information would altogether affect the generally encounter. Ease of making, adjusting, deploying, and the assortment of extensibility of visualization was chosen by 40% and 30% users, respectively, proving that versatility and adaptability are must-have qualities.

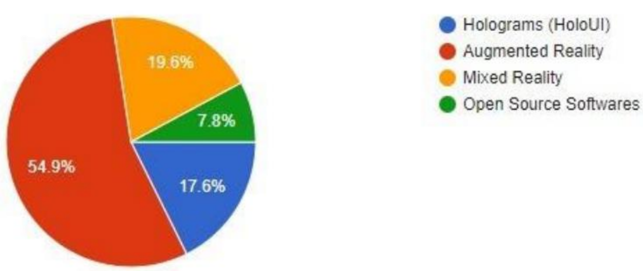


Figure 2: *Which Immersive Technology is the future of Data Visualization.*

When the users were asked about their views on the technology that would take the data visualization scenario to a different level, the results were one-sided as more than half of the surveyed users selected augmented reality. After which, 19.6% and 17.6% of users chose mixed reality and holograms, making it clear that the user interest in data visualization is highly inclined towards the extended reality sector.

III. PROPOSED ARCHITECTURE AND MODEL

The market analysis displayed within the past segment and the current state of art gives rise to the need to define and structure models that permit us to visualize data in a 3-dimensional space or utilizing Augmented Reality. The Data State Reference Show was created by Chi and Riedl within the late 1990s (in Chi & Riedl, 1999, and Chi, 2000), with the point of helping researchers to imagine and extend understanding of spatial plan, as well as to set up a system in which the individuals who carry out the execution can apply a more successful strategy of visualization of the data.

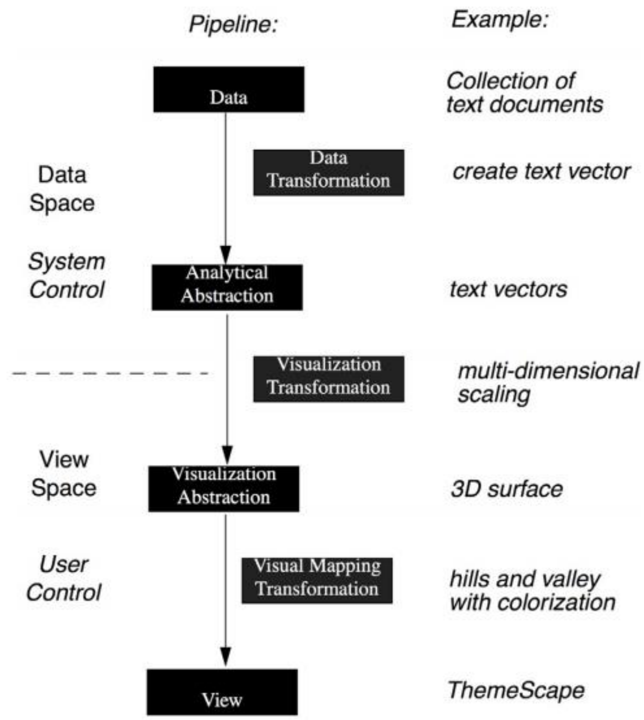


Figure 3: *The Information Visualization Pipeline, taken from Chi and Riedl (1998). For further information on the proposed model, see also Chuah and Roth's Basic Visualization Interaction taxonomy (in Chi and Riedl, 1998).*

In spite of the fact that the model dates from the late 1990s, it is interesting to watch how its arrangement serves to create ensuing devices and strategies for interactive data visualization, such as data visualization program (Heer et al., 2005) or think abouts that investigate the visual dimension of data mining and data preparing (De Oliveira & Levkowitz, 2003). In conceptual terms, our architecture is based on present day speculations of data visualization.

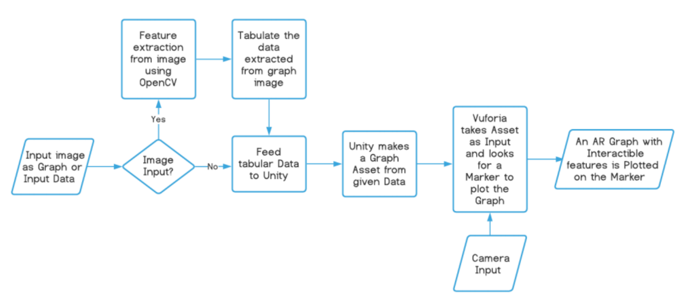


Figure 4: *Architecture proposed in current research based on the market analysis and current state of art.*

gARphics employments a Unity engine to plot the charts from the dataset and Vuforia SDK to render them in a real-time environment. The method begins with the application inquiring the input type, whether it may be a chart or a data set. On the off chance that the user chooses a chart the feature extraction from the image would be done using OpenCV, and the

extricated data would be organized, which would at that point meet the function where the tabular data is encouraged to Unity. In the event that a client specifically inputs the data, the same information is straightforwardly bolstered to Unity. Unity at that point makes the chart from the given data set and passes the charts to Vuforia SDK. Vuforia then takes the camera input from the gadget and a 3D chart is produced which is at that point rendered with the genuine time environment.
Apart from the user, gARphics has four major helps viz. Unity engine, Vuforia, user gadget, and user interface. The full handle of the current model can be summed up in ten steps.

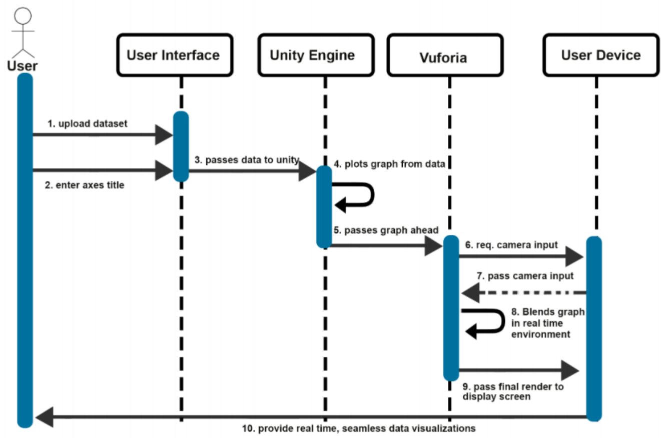


Figure 5: *Sequence Diagram of the Proposed Model*

Step 1: User uploads the dataset from the UI.

Step 2: User defines the Axes as they would be represented in the final output.

Step 3: The dataset is passed to Unity.

Step 4: Unity runs the coded script that plots the graph from the given dataset.

Step 5: The created graph is then passed to Vuforia.

Step 6: Vuforia requests camera input from the device to capture the real-time environment.

Step 7: The current environment is sent to Vuforia by the device camera.

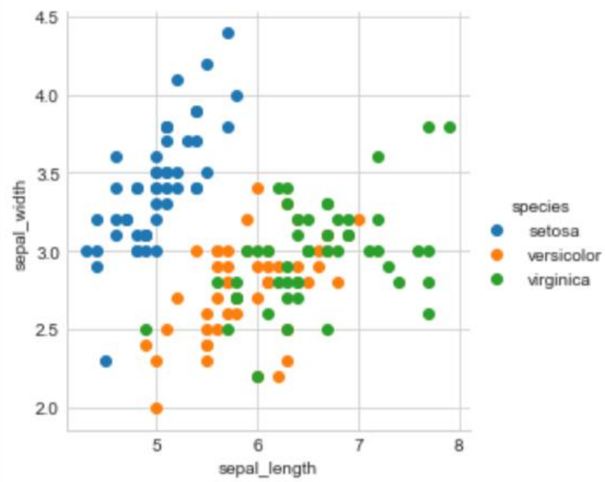
Step 8: Vuforia renders the 3D graph according to the environment.

Step 9: Vuforia passes the real-time and immersive data visualization to the user screen.

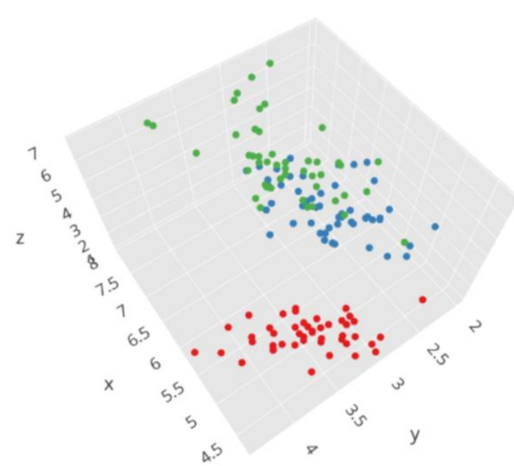
Step 10: The visualization is passed to the user, where he can interact with it.

IV. EXPERIMENT: MODES OF VIEWING

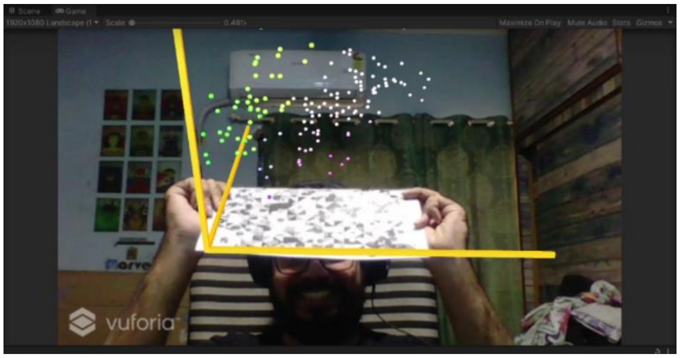
The address we were inquiring in this experiment was "How distinctive is an AR interface than a 2D – or 3D – on-screen interface for data visualization. In order to urge a quantitative assessment, we went through numerous customary visualization strategies which are utilized very as often as possible. Ekaterina Olshannikoval, Aleksandr Ometov1 et.al in their paper said the customary data visualization methods like histogram chart, line chart, scatter plots, LOESS curve, pie charts, bubble graphs, ER diagram, and Venn diagram. In spite of the fact that these strategies are most commonly utilized, there are numerous other strategies which are not so commonly utilized or compared such as parallel co-ordinates, tree-maps, etc. Visualizations can be static and dynamic as well. Visualization being interactive, user can profit the facilities such as zooming, looking over, panning, etc. Interactive visualization plays an imperative part in unmistakable user interfaces.



6.1. *2-Dimension on-screen condition*



6.2. 3*-Dimension on-screen condition*



***6.3.** Augmented Reality (AR) condition*

***Figure 6:** Modes of Viewing*

Three seeing conditions (Figure 6) were employed:

1. 2D on-screen interface: The Iris Dataset Scramble Plot was shown on screen using Python. A library named as Seaborn was used. The watcher was not permitted to zoom towards and away from the projection plane using the right mouse button. There was no revolution of the model.

2. 3D on-screen interface: The 3D chart was appeared on-screen on a grey 3-D plane matrix to imitate the the scatter plot within the AR condition. The subject used the left-mouse button to turn the viewpoint relative to the 3D chart in a trackball-like fashion.

3. Expanded Reality Interface: The primary model was exceptionally basic. The data points from that dataset were taken and plotted within the 3D engine unit. We started to draw the dabs in a Unity 3D environment, and once the plotted chart was accurately delineated, we went on to combine it with Vuforia SDK to grant it a living plot. We have made our first working AR prototype after this strategy has been effectively actualized. We have been working on the user interface and integration of our modules after great center operation to turn our prototype in low constancy into a high-faith prototype. Axes and color-coded nodes were included for accomplishing the objectives said over.

PARTICIPANTS

Ten subjects took part in this experiment, ranging between 20 and 25 years old, with the normal age being 22. The female to male proportion was 3:7. Two of the subjects were using Android 9.0; and the eight subjects were based on the most recent Android Version.

RESULTS

The results can be summarized in Figure 7 which was to rank the three interfaces/conditions within the arrange in which they favoured the data displayed, with 1 being the condition most favoured, and 3 being the least**.**

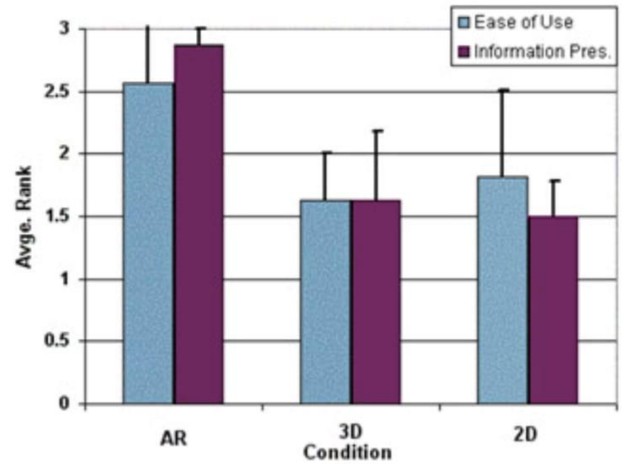


***Figure 7:** Ease of Use and Information Preference*

The following address was “rank the three interfaces/ conditions in terms of ease of physical control of the position and orientation of the graphic” with a score of 1 being the most straightforward and 3 being the foremost troublesome (see figure 8).

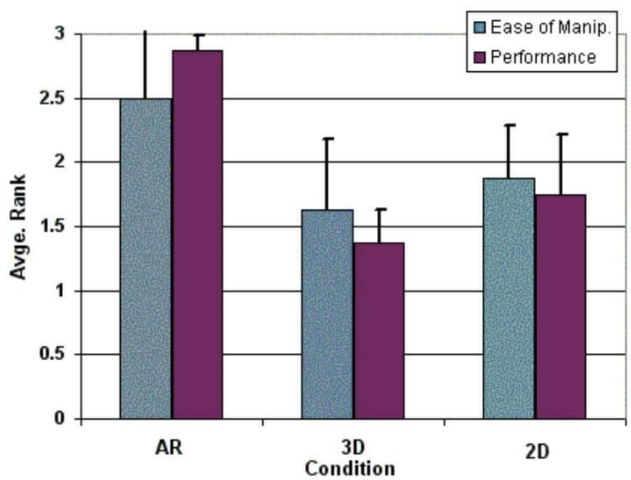


***Figure 8:** Average Rankings of Ease of Manipulation and How Well Task Performed*

V. USE CASES

Thanks to gARphics, users will be able to explore their datasets in multiple dimensions using our app. Another advantage of the use of AR for data analysis, is that the application easily integrates with day-to-day tools that are already a part of users’ workflow.

For this we envision two main use cases:

Data Exploration: Data scientists utilize Immersive Technology at several phases during the Exploratory Data Analysis. They tend to spend an immense amount of time and energy trying to present the findings of their effort.

The majority of the data operation, processing, and analysis would still take place in spreadsheets. While the bulk of the data manipulation and analysis would still take place in notebooks, 3D data visualizations are an important tool that enables the user to see the effects of their work, confirm their analyses, and make further observations. 3D visualizations are a vital step that enables the user to see their work's effects, concludes their research, and further examines.

Data Presentation: People spend a lot of time presenting the findings of their work. On a daily basis, they share discoveries and collaborate with colleagues. At the end of the day, they typically show their work to a manager. And on a larger scale, they need to present to stakeholders to secure funding and approval**.**
Users can use our app to share discoveries and to present to managers or stakeholders. They can save visualizations to take their audience on a visual journey. 3D visualizations help tell a coherent story about the data and allow the stakeholder to better engage and understand.

VI. FINAL PROTOTYPE & RESULTS

With our investigate and market analysis, we ought to know the user needs and how well they can provide users a great encounter. We finalized Unity as our centre stage and select Vuforia after comparing it with its different competitors like AR centre, AR kit, and AR establishment.
We started checking on research papers and composed our first review paper that compares all the current platforms accessible within the data visualization range. In conjunction with the review paper, we begun creating our low-fidelity prototype and strategized to change over it into our first working prototype.

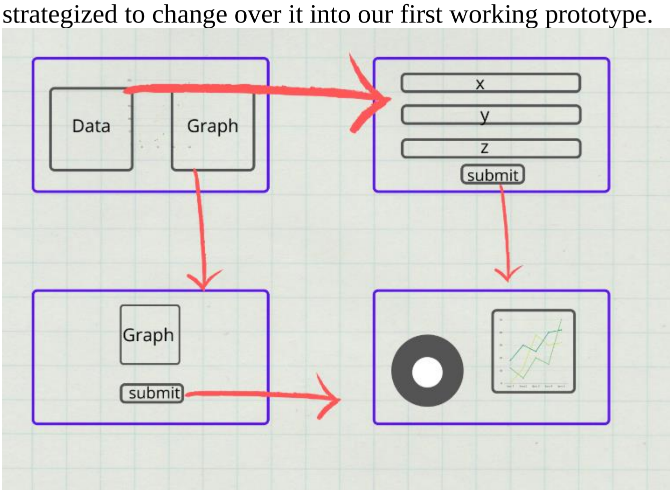


Figure 9: *Low Fidelity Prototype*

Our first model was exceptionally fundamental. It took the data points from the given dataset and plotted them within the Unity 3D engine. We began with plotting the points in a Unity 3D environment, and once it spoken to the plotted chart precisely, we moved on to coordinated with Vuforia SDK to bring the plotted graph to life. After successfully executing this process, we created our first working AR model (Figure 10).

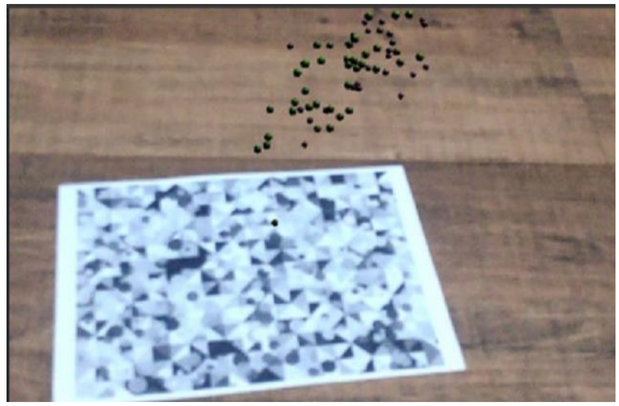


Figure 10: *First AR Prototype*

After the successful core working, we worked on the user interface and integrated our modules to change over our low fidelity model to a high-fidelity prototype (Figure 11.1). Once the primary adaptation of the application was conveyed, the team overhauled the current adaptation to improve the user experience and ease of data visualization. After which the UI/UX was designed (Figure 11.2) and Axes and color-coded nodes were included (Figure 11.3) for accomplishing the objectives specified over.

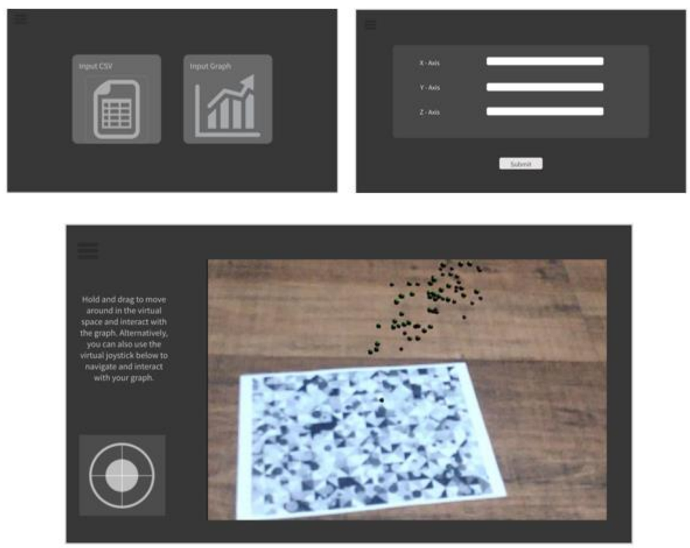


Figure 11.1: *High Fidelity Prototype*

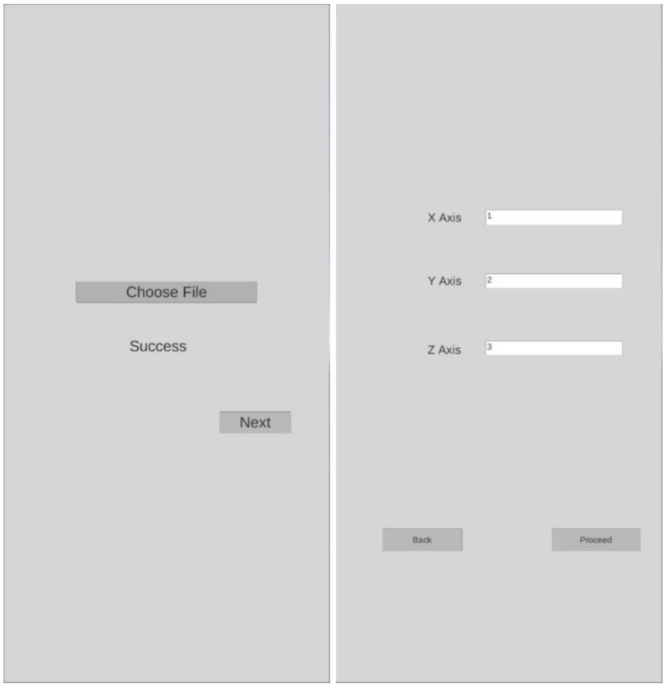


Figure 11.2: *Basic UI/UX*

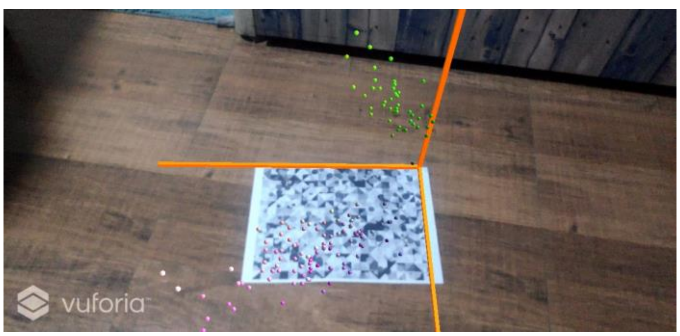


Figure 11.3: *Colour Coding and Axes*

We needed to give our users a cross-platform and consistent information visualization experience. We decided to take the Android stage experience and created our model that worked on the android stage (Figure 12).

As we have already examined, AR's scope as technology is endless, and there's a tremendous scope for future upgrades. We are using an Agile strategy that helps us upgrade and more highlights to the application after each emphasis. We are currently adding names to the data points to create it simple for clients to get it the plotted graph. The modular nature of the application empowers us to upgrade certain regions of the code and overhaul and make strides the application.

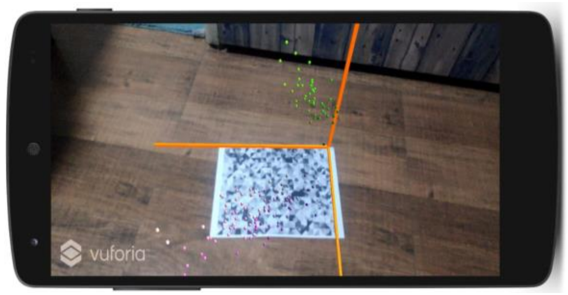


Figure 12: *Android Prototype*

VII. CONCLUSION & FUTURE SCOPE

The project was to make a viable data visualization platform using AR to provide easy-to-interpret results notwithstanding the complexity of the dataset. Point by point research has been done to understand the user needs and behaviour and the technology integration in this specific field. A review paper was written that compared the current state of the art within the data visualization range and given understanding on AR as a data visualization technology.

AR could be a relatively modern innovation, and thus it encompasses a tremendous scope, and so does the project as a few highlights can be included to the extend. Long haul scope of the project incorporates graph plotting with image input. Data can be extricated from the graph image using OpenCV, and a 3D graph can be plotted in real-time using the same handle. Adding to our future scope, we point to extend the plotted graph's adaptability and recalcitrance to analyse the visualization precisely. We also point at making our model marker less to create the experience totally seamless.

As discussed within the over sections, an application was made that fulfills our issue articulation and gives a seamless and immersive data visualization experience using AR. The point, problem statement, and user needs were kept in mind throughout the project's advancement stage. Regular overhauls are being included to progress the user involvement and give way better results. The application was tested at different levels to guarantee its unwavering quality and integrity. The project will be profoundly beneficial to the user. It'll offer assistance within the successful and interactive visualization of complex and large datasets with a single click and negligible issues and complexities. This Project Phase has given us insight into the actual project world culture and has bridged the hole between the academics and the Advancement that drives the world. Working with the team, creating the project, and understanding issues beneath the Project Stage were productive and included noteworthy value to our technical experience.

VIII. REFERENCES

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