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IOT-ENHANCED AUGMENTED REALITY FOR MECHATRONIC SYSTEMS: ADVANCING COMMUNICATION EFFICIENCY AND VISUAL ANALYTICS INTEGRATION

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ABSTRACT

This research delves into the integration of the Internet of Things (IoT) into virtual communication platforms, specifically focusing on Augmented Reality (AR) applied to mechatronic systems. The primary goal is to explore how IoT and AR can synergize to improve communication efficiency and enhance user experience in mechatronic environments. Augmented Reality (AR) enables users to create and view virtual objects in physical 3D space. However, configuring AR technology, especially for displaying augmented information via QR codes on mobile devices, remains a challenge. The current research project addresses this by developing a framework for augmenting visual analytics and integrating it into mobile apps to provide dynamic representations. The analytics are sent to the Unity engine to embed them into the AR application. Tuning hyper parameters facilitates the examination of their impact on classification. Nine different classifiers, including J48 decision tree, Hoeffding tree, Random forest, Random Tree, REPTree, Bayes net, Naïve Bayes, OneR, and Decision table, are constructed and compared for optimal performance. The findings contribute to advancing the understanding of how IoT-assisted virtual communication on AR platforms can revolutionize mechatronic applications, fostering innovation and efficiency in this rapidly evolving field. The AR application utilizes predictive classification to enhance visualizations, and the OneR classifier, combined with monarch butterfly optimization, is recommended for the Walmart dataset due to its maximum accuracy of 92.3322% compared to other classifiers.

INTRODUCTION

In the era of Industry 4.0, the convergence of advanced technologies has redefined the landscape of mechatronic systems, offering unprecedented opportunities for innovation and efficiency. Among the transformative technologies, the Internet of Things (IoT) and Augmented Reality (AR) have emerged as pivotal forces reshaping the way we interact with and perceive mechatronic environments. This research delves into the intersection of these

two realms, investigating the potential of IoT assisted virtual communication within the context of AR applications for mechatronic systems [1].

Mechatronic systems, integrating mechanical, electronic, and software components, play a crucial role in various industries, from manufacturing to healthcare. The need for seamless communication, real-time data exchange, and remote monitoring in these systems has become increasingly apparent [2]. Herein lies the impetus for exploring how IoT can enhance virtual communication experiences within the immersive realm of AR, creating a symbiotic relationship that transcends the limitations of traditional communication interfaces.

The integration of IoT into AR for mechatronic systems holds promise for addressing challenges related to data accessibility, communication latency, and user engagement. By intertwining these technologies, we aim to establish a framework that not only facilitates effective communication but also enriches the user's interaction with mechatronic environments. Through a lens of practical application, this research aims to unravel the potential benefits, challenges, and transformative impacts of this amalgamation [3].

Data has always been an important aspect on every front of human's life. It is available in a huge amount everywhere. The amount of data is growing exponentially whether there is the use of existing data or data being created. As per the survey, it is expected that 74 zeta bytes data generation will occur until the end of 2022 and will double in 2024 [4]. Data is a term that denotes a huge set of the dataset which tends to grow over a period of time span exponentially. There are three forms of data, i.e. an organized, unorganized and semi-organized. Data can be explained as the parsed information through a digital system that can be read, analyzed, and conveyed in knowledge. Data digitalization plays a vital role in the 21^{st} century owing to benefits offered to the end-users in the form of knowledge, facilities, and decisions. Data analytics can be defined as the process of decision making in the form of conclusions.

RELATED WORK

In an era of AR and VR, data visualization has gained a lot of importance. Data visualization is an art that can be mastered with practice to visualize them in various ways. In tune with the motivation of marker-based augmented reality technique for visualization data analytics, the literature related to data visualization, augmented reality, multiple tools available for AR and their comparison, use of mobile devices of AR etc., has been carried out and presented accordingly.

Data analysis can be defined as an exploratory process often initiated through specific queries. It usually requires a deep analytical skills to identify and analyze the answers. Often, it includes the deep analysis and examination of the user data to draw valuable conclusions about a particular parameter or set of parameters [7]. Data analysis includes data cleaning, validation, estimation processes, along with visualization. Data analytics include a collection of statistics, mathematics, programming, problem-solving, data capturing in innovative ways, the desire to view things in new ways, and the activity of cleansing, planning and aligning data. Data analytics deals with structured and unstructured data. Data analytics is used in various application areas such as digital advertisements, internet research, recommender systems, image/speech recognition, etc. The tools and languages used are Python, SAS and SQL, etc.

Data visualization includes plotting data and selecting the proper type of charts to understand better the data and reporting purposes in more interactive and professional goals. On the other hand, data visualization involves the visual representation of data through comprehensive charts, graphs, lists and other visual elements [8]. These data visualizations methods facilates the users to comprehend and extract the information in a short period of time. Moreover, it makes complex information easier to be read for the masses.

Datasets are mined and employed in numerous application areas, for example, communication, retail, financial services and education, etc. The tools and languages used are Hadoop, NoSQL and Hive, etc. The discipline of exploring raw datasets aimed at explicit inferences is recognized as data analysis. Different types of analytics available are predictive, prescriptive, descriptive and diagnostic [9]. A brief idea about these types is stated herein. The predictive approach in this type of analytics deals with the fore- casting problem for any dataset and is usually solved by regression analysis. The value displayed is the prediction that might happen in future. The descriptive approach is the simplest analytics class, condensing a whole data into smaller nuggets of information. The prescriptive approach is an advanced analytics concept that helps to achieve the best outcomes. An example would be prescribing the credit score, which eventually helps the organizations to decide the probability of the person to pay bills on time. Diagnostic approach is useful for the identification of the anomalies and determining casual relationships in data [10].

Data analysis offers many advantages, mainly the aptitude to speed up policymaking and evade fake actions. Prescriptive analytics is the process of using data to determine an optimal course of action and combination of descriptive and predictive analytics.

Prescriptive analytics is important, however generally not utilized [11]. Where large information analytics overall relates perception made about a topic, prescriptive analytics offers a careful attentiveness to response detailed investigations.

A prescriptive approach could be applied to some business goal or matter essentially. Prescriptive analytics utilizes huge information to distinguish previous instances and anticipate what is coming in the future. Some businesses use this kind of analytics to deal with lead scoring. In the medical field, one may more easily agree to a patient group by first utilising this analysis to determine the amount of patients with clinical courage, and then adding stations for conditions such as cholesterol levels and diabetes to determine where to focus therapy. A handful of groups practised, in addition, to use these analytics for an entire deals measure, breaking down the principal cause, a number of correspondences, sorts of exchanges, web-built media, records, information, and hence suitably modified prescient analytics could be used to assist deals, promoting, or for diverse states of mind-boggling approximations. Expressive inspection is used to reveal or choose the reason behind something that occurred [12]. There exists a considerable amount of notifications highlighted online, which could be distinguished into a unique view for examining what has chalked out in previous campaigns and what has not. Data mining is at the foundation of the tremendous data regard chain, yet it could be huge for uncovering models that offer information [13].

Data filtering includes selecting a small part of a data, i.e. a subset of information and using that subset for viewing or analysis. Filtering includes doing calculations on a small set of data [14]. Filtering necessitates the creation of a rule or logic to determine which cases should be included in the analysis. Filtering is also known as ‘sub-setting’ data or a data ‘drill-down’.

The main purpose of data filtering is done to make it easier to concentrate on specific information in a huge dataset or table of data. The various sorts of data filters could be employed for amending reports, querying results, or extra styles of information results. One important reason for data filtering is to remove observations that may include errors or are undesirable for an analysis.

Additionally, with data filtering, one might accomplish critical outcomes for the execution of measurable calculations and models. The primary thought behind data filtering is to partition the example into at least two gatherings and, then, at that point, apply the investigation to each gathering independently and look at the outcomes. The sort of filtering would choose cases aimlessly instead of utilizing some standard that depends on the data [15].

Augmenting reality is altering and expanding cognitive reality (experience). It enables ambient computing and extends our potential and experience to the limits of technology. It extends social connectivity and sharing into every mode of experience. It is a continuum towards virtual reality. It allows the software to replace most physical tools and materials, phasing out dependence upon physical reality. It eliminates many of the constraints of physical reality, bypassing physical laws and resource availability and doing away with physical existence as a prerequisite to the experience of an object or place. Augmented Reality may not have taken a matured concept of being a fully recognizable technology, but on the ground of its skyrocketing popularity from countries all over the world, leave no room for doubt as to the future of AR is going to be developed in such a way that it would dominant its counterpart technologies. However, it cannot be professed clearly as technology is usually replaced with incoming ones, thus making the old ones an obsolete gizmo [2].

Devices such as Wikitude, Layar, Alive app, Areal app (Adstuck), i-Tag action figure etc., are used to take the magical experience of using AR. Moreover, if used by smart phones, the technology usually needs accoutrements such as GPS, accelerometer, GPRS, gesture recognition, and object identifiable technologies. Remember that they are part of the AR function as per the technique involved. For instance, Wikitude is an augmented reality browser that allows users to obtain information about hotels, restaurants, schools, play games, railway stations etc., from their physical surroundings [5]. They have to train their camera on the surroundings while the Wikitude app will capture the view with a subsequent output of related inputs. Augmented reality involves superimposing data and images over what anyone can see in the real world. This is al- ready being done with smart phones where one can hold it up to see local information directions nearby. It is also being tested by the military to aid in situational awareness. Microsoft Hololens and similar technology from other companies already promise to augment our vision [5]. And yes, it will be connected to the Internet for keeping track of location and activity.

PROPOSED RESEARCH METHODOLOGY

Interesting material can help people understand it better by letting them connect with it. Through the aid of hologram-based representation, people can work together better. The part talks about how virtual reality affects how we understand and share information [14].

Surveys are essential to the process. The survey instrument collected a group's opinions and observations to determine how well holograms improve virtual communication. The poll questions individuals on their experience with virtual reality representation, understanding, and holographic effectiveness. Surveys provide organized and quantitative replies. Due to

system complexity, several perspectives are crucial. Quantitative research often uses surveys to acquire data from a representative sample and improve generalizability [17].

As stated by Benckendorff, Xiang and Sheldon, the study examines virtual interaction in augmented reality (AR) for electronic systems. AR helps participants grasp complicated facts, and participants are informed. By designing questions around the study's main goals, the questionnaire may measure holograms' influence on online interaction. The quantitative nature of the methodology allows for statistical analyses of survey responses, as well as the identification of correlations and trends in participants' perception [18]. The research's overarching goals are supported by the approach that gives a strong foundation for drawing empirical conclusions about the effectiveness of HoloLens.

The nature of augmented reality makes the decision to use surveys logical. A nuanced understanding of the relationship between virtual communication and visualization can be found with the use of quantitative metrics. The integration of surveys allows for the capture of diverse perspectives, considering the varied background and expertise prevalent in mechatronic research and practice. This approach tries to encompass the diversity within the quantitative analysis by acknowledging the interdisciplinary nature of the systems. The survey methodology quantifies user experiences, but also enhances the research by incorporating a variety of perspectives relevant to the landscape [19].

Input dataset

As per Kelly et al. [15], the tools and languages used in this research are crucial in shaping the exploration of raw datasets. Virtual communication on augmented reality is related to the use of these tools in the realm of mechatronic systems. Mechanistic systems need sophisticated data handling due to the convergence of mechanical and electronic components. A distributed storage and processing framework helps manage a lot of data. It can handle diverse data sources and contribute to a comprehensive understanding of the system.

The data structures prevalent in the mechatronic datasets can be seen in the databases that cater to them. As a result of real-time interactions and feedback loops, NoSQl databases provide the necessary responsiveness to enable the research to dive into dynamic data patterns crucial for virtual communication enhancement. Hive is able to bridge the gap between the need for structured analysis and the complexity of the data. The research's emphasis on virtual communication improvements is aligned with the role it plays in facilitating the extraction of meaningful insights from the datasets [11].

Model evaluation

The model consists of a predictive classification algorithm that takes the pre-processed Bigmart dataset as the input and outputs the predictions in health, unhealthy, and both target variable categories. The dataset was transformed using data transformation techniques such as data generalization, aggregation and data smoothing at the final step. The dataset consists of 15 attributes, including the class label and after computing the values of selected attributes of the dataset to make it favorable for supervised learning. The final cleaned and the imputed dataset was forwarded to our machine learning algorithms for classification. The ‘Bigmart’ dataset has been considered and provided as an input to the python code for executing classification with respect to item type, outlet size, and health status using machine learning. The dimension of BigMart dataset is stated here [16]. The number of samples is 8524. The number of features is 1,44,891. The number of attributes is 17. The target labels were health

status, item type, and outlet size. Later, the visualizations of classification were obtained in the form of analytics. The analytics are further forwarded to the unity engine for embedding it with the augmented reality application. The application consumers can view the data analytics by installing the application from the cloud without any extra documentation or reading materials. The hyper parameters tuning has assisted in investigating the impact of those parameters for predictive classification [16]. The best predictive classifier out of the comparative group is then recommended. Nine different classifiers such as the J48 decision tree, Hoeffding tree, Random forest, Random tree, REPTree, Bayes net, Naïve Bayes, OneR, and Decision table have been designed for achieving this purpose. The classification obtained from the predictive classification is forwarded to the augmented reality application for augmenting the visualizations and displaying 3D views to the end-users [17].

The input dataset goes through a preprocessing data phase where the noise is cleaned, and outliers are removed for obtaining a pure dataset for predictive analysis. To clean the noise from input dataset every single entry is checked and if any feature value is missing in dataset then that entry is made zero in such a way noise is cleaned [18]. The imputed data was provided to the supervised algorithms for obtaining prediction results and accuracy scores. The visual analytics are further provided to the user and the marker-based augmented reality application. Augmented reality is an advanced technology that expands actual conditions on a cell phone screen by overlaying them with computerized content. augmented reality applications can utilize various techniques like associating PC created substances to ‘markers’ or deciding where to add information with GPS to superimpose computerized data. A quick response code, also known as a 2D code, can be augmented using software development kit and tools for augmented reality applications [19]. The augmented information can be displayed on the de- vice’s screen via a camera when it detects the augmented targets on the quick response code image.

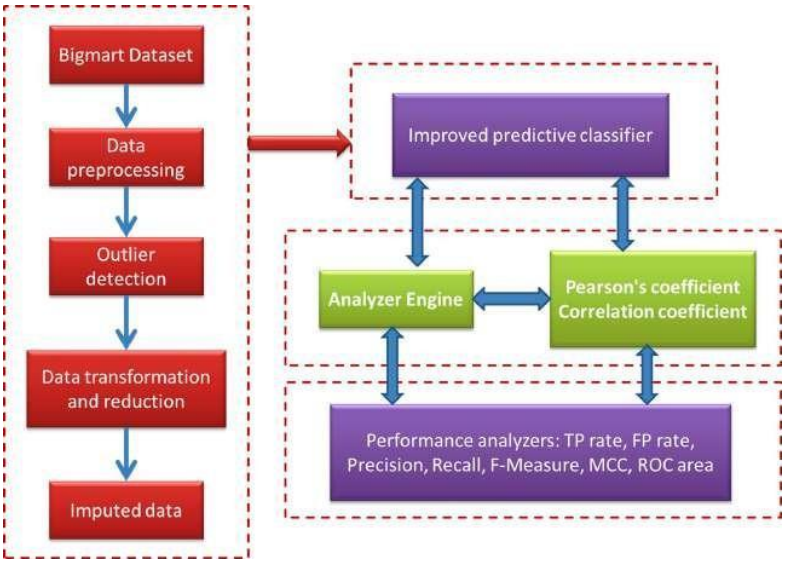

Figure 01: Model for analysis and visualization of Bigmart dataset using mobile device

The augmented reality application developed in Unity engine is given tier 1. The graphs are embedded in the application for displaying on the user's screens. The virtual reality plugin required with unity is Vuforia and be installed in the unity engine. Fig. 2 shows two tiers for model implementation.

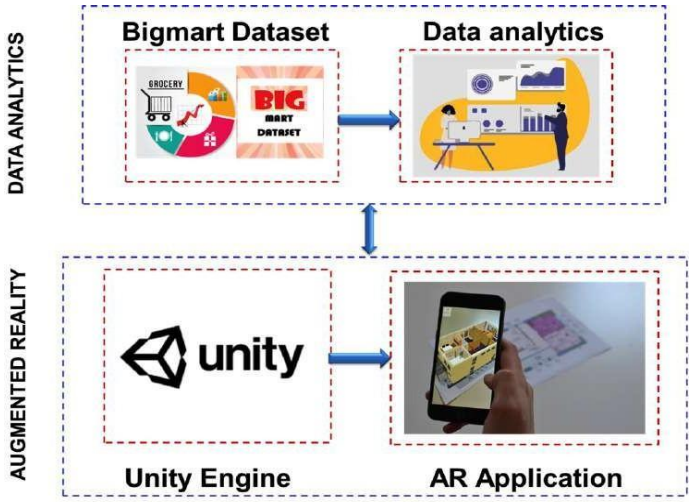

Figure 02: Two tiers for model implementation

The J48 algorithm is used to generate a tree-based classifier model to classify the data items present in the dataset. The C4.5 is an extension of Quinlan's ID3 algorithm. Quinlan's ID3 algorithm and J48 algorithm is used to implement the univariate decision tree approach. A univariate decision tree approach uses a single feature to split the internal node. The different types of nodes present in the model are the internal node consisting of the splitting attribute and the leaf node with the class name. The ID3 algorithm uses concepts like information gain and entropy in choosing which attribute to select as the splitting attribute to minimize the loss. Let us see what the terms information gain and entropy mean.

Table 1 Classifier chosen for family

Family	**Classifier chosen**
Tree	J48 decision tree
Tree	Hoeffding tree
Tree	Random forest
Tree	Random Tree
Tree	REPTree
Bayes	Bayes net
Bayes	Naïve Bayes
Rule	OneR
Meta	Decision Table

Important nomenclatures in decision tree J48 Algorithm:

- **Root node:** As the name mentioned, this is the main node from where the branch- ing of nodes starts.

• **Decision node:** when a node is going through bifurcating to obtain more branches, then the node is called decision node as the decision is to be made on a data point to classify it.

• **Pruning:** This is the process of deleting some part or sub-branch of the tree. This is majorly used for preventing the model from over fitting the training dataset.

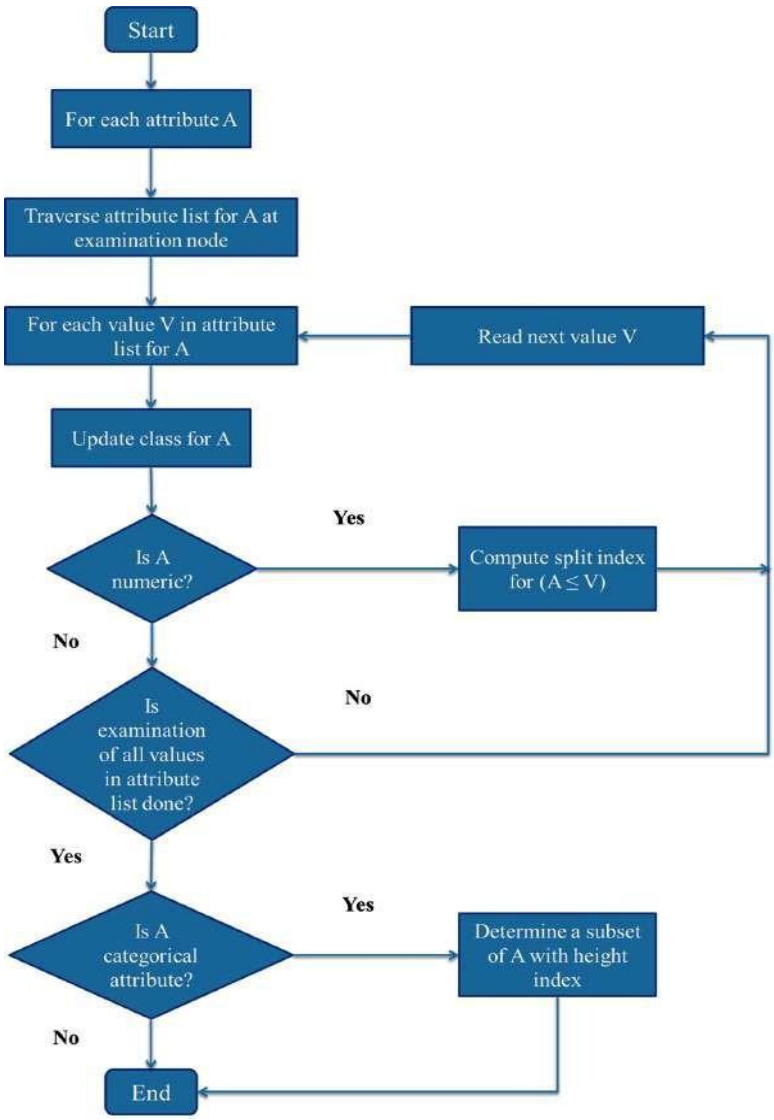

Figure 03: Flowchart of decision tree J48 algorithm

The first step in this algorithm is to recognize the whole training dataset as the main node. The preference of the dataset for this type of algorithm is to be categorical data. If the dataset is not categorical, it is converted into categorical by techniques like discretization and normalization. This algorithm is recursive. The placement of deciding attributes such as columns in the dataset is decided by using statistical analysis. The main objective of this algorithm is to arrange the attributes of a dataset in a depth manner, such as top-down or bottom-up. This arrangement of attributes will make a strategy for a

model to make decision making. Thus, this step is crucial for the algorithm as it can decide the model's accuracy.

RESULT ANALYSIS

The present model comprises of vuphoria SDK, camera, image converter, tracker video background renderer, application code, device database. Every preview frame is recorded and effectively transmitted to the tracker by the camera component. The pixel form converter converts the camera format to an OpenGL ES displaying and tracking format that may be used internally. The tracker component includes computer vision algorithms for detecting and tracking real-world objects in video frames captured by the camera. The outcomes are saved in a state of the object used by the video backdrop renderer, which may be retrieved from the application code. The camera picture given in the state item is rendered using the background renderer. Inquiry about newly discovered targets, markers in the state object. With the new input data, update the application logic. Create the augmented images overlay and render it. The digital target manager is being used to generate the device database. The target manager API can be used to establish cloud databases. This functionality allows user to create targets from the existing camera image on the fly. With two recognition options, 'words' and 'characters,' the vuforia SDK can detect phrases and track them in the same way as other targets [17].

On the other hand, the proposed model is a marker-based technique. Marker-based is a technique in which virtual objects are created in the physical environment. The user has access to virtual objects in a real-world environment. Marker-based techniques can be implemented with fewer challenges using Vuforia target manager in unity 3D engine. The system implementation is divided into two tiers, such as data analysis and AR application development [3]. The Bigmart data is processed and inputted to the tableau big data analytics tool. The business intelligence tool processes the data with several analytical computations by finding a statistical pattern to share it with the consumers. After obtaining the visualizations, the diagrams are saved and embedded in the AR mobile application developed in the Unity engine and aided by the Vuforia plugin. AR Application Development - The augmented reality application developed in Unity engine is given the input from tier 1, and the graphs are embedded in the application for displaying it on the screens of the users. The virtual reality plugin required with unity is Vuforia and can be installed as a plugin in the unity engine application. The proposed model consists of designed classifiers that take the pre-processed Bigmart dataset as the input and outputs the classification with respect to item type, outlet size, and health status. The Bigmart dataset consisted of missing values, and therefore the noise was cleaned using outlier detection practices such as box plot and histogram visualization [4]. The dataset was transformed using data transformation techniques such as data generalization, aggregation and data smoothing at the final step. The class labels were assigned manually after computing the values of all 13 attributes of the dataset in order to make it favorable for supervised learning. The final cleaned and the imputed dataset was forwarded to the machine learning classifier for classification. The confusion matrix is visualized in 3D form. Table 4.2 depicts the comparison of the existing model and proposed model.

Table 02: Comparison between Marker less and Marker based system

Marker less AR existing system	**Marker based AR proposed System**
Depends on localization	Relative position is marker Dependent
Technology and gyroscope	Software development kit commonly used
Position accuracy is lower	Position accuracy is higher
Position accuracy is dependent on localization technology	Position accuracy is dependent on brightness

Data processing

This graph's analytical conclusion is the maximum sales of a particular item type in the retail store. This finding or knowledge would help the stocking manager or store manager decide that would result in higher sales with high demand [7]. The data analytics obtained in this module are forwarded to the unity engine as inputs, and the visualization is produced in 3D format on smart devices. The next section details the AR application developed for augmenting the statistical information.

Table Categories Summary

Item_Type	Item_MRP	Item_Outlet_Sales	Item_Weight	Number of Records
Fruits and Vegetables	147,189	2,219,978	13,476	1,019
Snack Foods	144,949	2,194,045	12,832	988
Household	113,210	1,659,037	10,159	759
Frozen Foods	99,962	1,494,210	9,239	718
Dairy	84,526	1,244,133	7,599	566
Canned	75,053	1,155,262	6,633	539
Baking Goods	67,588	1,027,220	6,581	536
Health and Hygiene	56,384	835,171	5,651	430
Soft Drinks	49,295	735,962	4,431	374
Meat	47,160	689,281	4,319	337
Breads	28,663	437,771	2,315	204
Hard Drinks	25,262	377,067	2,086	183
Starchy Foods	19,200	301,063	1,780	130
Others	18,625	280,482	1,898	137
Breakfast	12,696	178,104	1,136	89
Seafood	7,398	128,722	640	51

Item_MRP, Item_Outlet_Sales, Item_Weight and Number of Records broken down by Item_Type.

Figure 04: Data aggregation of all the dataset attributes (S., 2019)

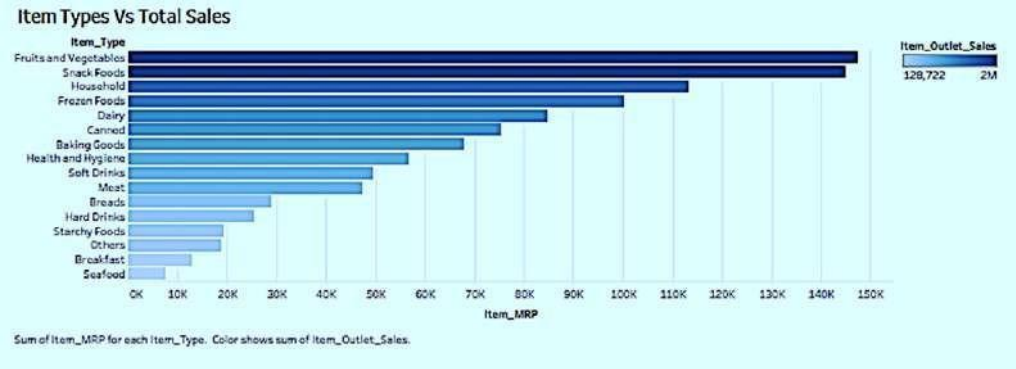

Figure 05: Bigmart data: Item Type vs. Total sales

Unity engine for interactive AR

Vuforia is an augmented reality SDK that primarily focuses on the mobile applications. The SDK combines computer vision and machine learning which allows advanced artificial intelligence. Vuforia supports 2D and 3D targets, including marker less image targets. The image provided in the Vuforia database is augmented by the engine itself through the target manager online.

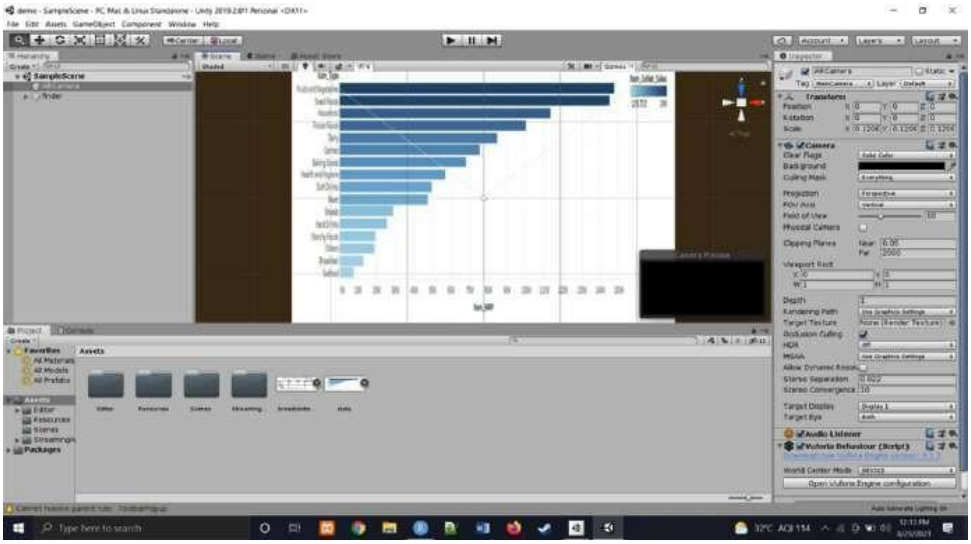

Figure 6: Screenshot showing the development of AR app. in unity engine

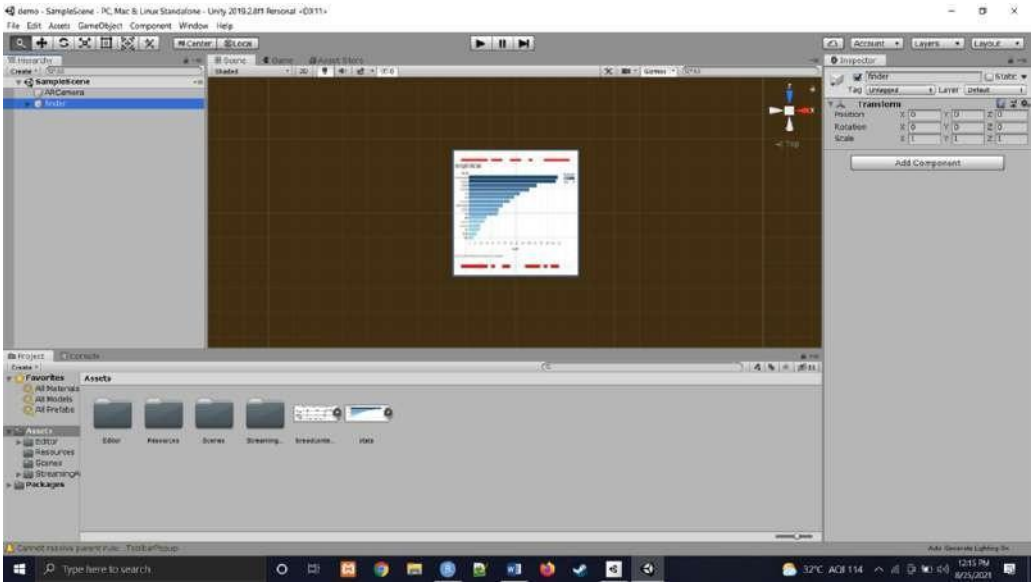

Figure 07: Properties of the overlaying augmented imaged in unity scene 3D

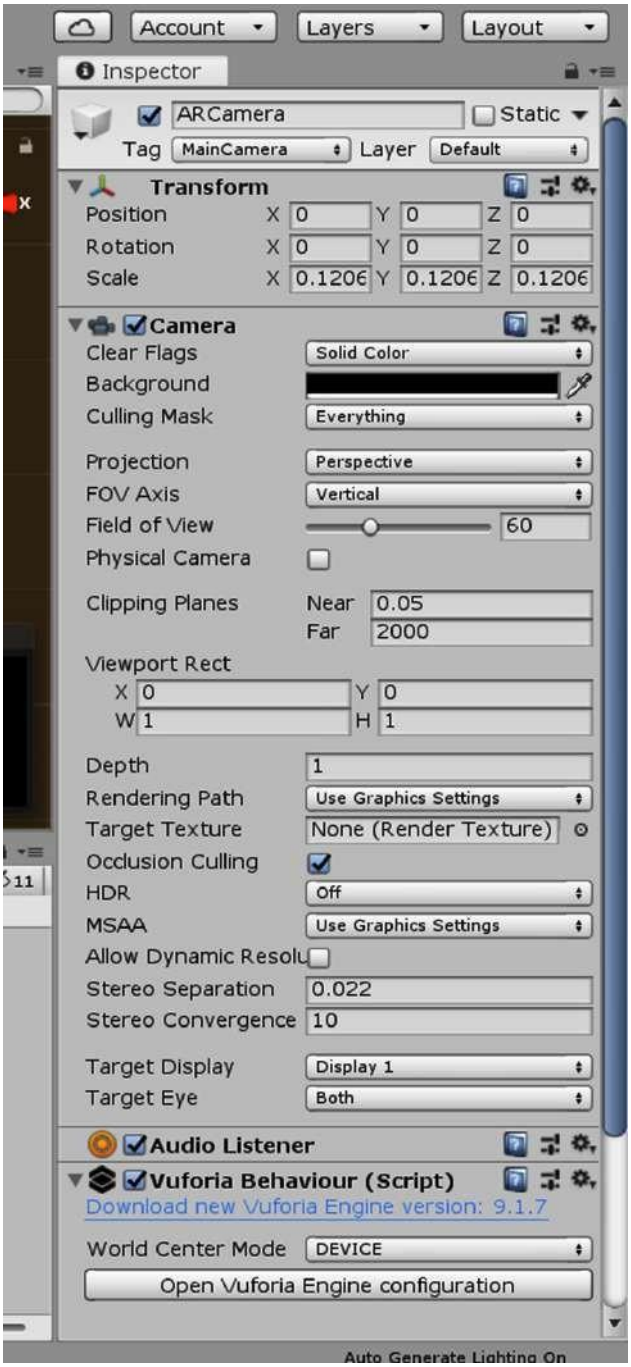

Figure 08: Properties and configuration of AR camera in unity

The ‘Bigmart’ dataset was considered and provided as an input and classification with respect to item type, outlet size, and health status using machine learning is presented using different classifiers such as J48 decision tree, Hoeffding tree, Random forest, Random Tree, REPTree, Bayes net, Naïve Bayes, OneR, and Decision Table. The methodology clearly classifies and visualizes the data appropriately in 3D form. The confusion matrix in 3D form is clear, easy to understand classification and misclassification. The four metaheuristic optimizers were employed to improve the classification accuracy that systematically assists hyper parameter tuning. Later, the visualizations of classification have been obtained in the form of a confusion matrix and forwarded to the Unity engine for embedding it with the AR application

for augmenting the visualizations and displaying 3D views to the end-users. The OneR classifier and Monarch butterfly optimization are recommended for the classification of item type and outlet size Bigmart data.

CONCLUSION AND FUTURE WORK

The methodology emphasized the development of augmented reality systems, which are responsible for displaying the virtual representation of statistics obtained from data analytics. The systems are designed to get 3D visual images that help transmit data to the human brain within seconds. A developed system allows outline problems, understand current trends, and visualize data from different angles through HoloLens. In the DVH model, the analytics obtained from the periodic table are embedded in the augmented reality device using Microsoft HoloLens. The interactive gestured visualizations are displayed in a virtual 3D space to the user with the improved angle of visualization and positional accuracy. Further in the MVMD model, the Bigmart dataset has been considered and provided input to the python code for executing classification for item type, outlet size, and health status using machine learning.

In 'Data visualization using HoloLens' (DVH model), an investigation considering three problems to discover knowledge from the Periodic table dataset was successfully carried out. All the periodic table elements were listed according to the atomic mass. After investigation, it is observed that the trend continues to grow upward, which proves that all the elements are listed in ascending order according to their atomic masses. The subsequent issue was identifying outliers from the major attributes such as 'Electro negativity' and 'First ionization' via a box plot graphical visualization. It is found that the tiny bubbles sprouting out of the box are the outliers. Later, the issue was listing the number of isotopes for all the periodic table elements. The pie chart showed that only a few elements like Neptunium, Plutonium, Americium, Chromium, Einsteinium, Fermium and Lawrencium had more isotopes. The end-users can visualize the modern periodic table in a 3D linear view and circular view and study individual elements of the periodic table by using the proposed framework of HoloLens II. It improves the angle of visualization and positional accuracy with the help of AR techniques. Thus the objective of augmenting the online mode of communication for school education in the case of the periodic table through HoloLens has been successfully demonstrated.

In 'Marker-based visualization using mobile device' (MVMD model), the bigmart dataset was considered and provided input for classification regarding item type, outlet size, and health status using machine learning classifiers. The methodology classifies and visualizes the data appropriately in 3D form. The confusion matrix in 3D format is clear, easy to understand classification and misclassification. The four meta-heuristic optimizers were employed to improve the classification accuracy that systematically assists hyper parameter tuning. Later, the visualizations of classification results are obtained in the form of a confusion matrix and forwarded to the unity engine for embedding it with the AR application for augmenting the visualizations and displaying the 3D views to the end-users. The oneR classifier and Monarch butterfly optimization are recommended to classify item type and outlet size of the Bigmart dataset, as it gives the highest accuracy compared to other classifiers.

The future scope would focus on animating the image characters projected by augmented reality. In the future, the methodology presented in this research can be extended further for space, automotive, manufacturing, and healthcare applications. The scope of the present work

can be expanded by considering virtual reality and mixed reality in combination with augmented reality for indoor navigation. Just like GPS-built in software and maps direct us towards a shop, hospital, or other places from outside, the augmented reality-powered navigation systems would assist people indoors. It will instruct the path towards any particular product, software, or location engagingly and effortlessly, giving them an optimal experience without relying on others. Emerging Extended Reality (XR) could enable practitioners to swipe between AR, VR, and MR elements at any given time. It would let the people access the required information and practice their skills in real environments without harming any real species. For example, with the help of XR technology, the medical students will be allowed to practice delivering a baby in the back of a cab with limited medical equipments.

DATA AVAILABILITY

The dataset used and analyzed during the current study is available in hugging Face, https://huggingface.co/datasets/tweet_eval/tree/main/offensive . The data is publicly available and can be used by the detection code for the empirical analysis of machine learning algorithms.

ETHICS DECLARATIONS

The authors declare no conflict of interest.

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