सामग्री प्रबंधन प्रभाग
भारतीय प्रौद्योगिकी संस्थान मुंबई
पवई, मुंबई-400 076, भारत

Materials Management Division
Indian Institute of Technology Bombay
Powai, Mumbai-400 076, India

Phone : (+91-22) 2576 8800, 8801 to 5, 5009, 8848
E-mail : drmm@iitb.ac.in
Website : www.iitb.ac.in

IIT Bombay

Date: -16/08/2021

Corrigendum –III

For (PR No. 1000016844) RFx No. 6100000745

Cubic Immersive Virtual Reality System

Sr. No.	Online RFx Clause	Previous Clause	Changed Clause
1.	Bid submission End Date/Date & Time of submission (Online RFx clause)	20.08.2021 at 13.00	30.08.2021 at 13.00
2.	Bid Opening Date & Time (Online RFx clause)	20.08.2021 at 15.00	30.08.2021 at 15.00

*** The following information is additionally added in our tender.**

for Additional Registrar

Materials Management Division

Usage of Cubic Immersive Virtual Reality System

RFx No. 6100000745 (Reference No. 1000016844)

1 Primary usage

Visual analytic systems have made a valuable contribution to understanding the structure of data by presenting humans with the visual perception of data. However, these systems have shortcomings in dealing with large-scale high-dimensional data. Hence, a virtual reality-based visual analytic system, so-called Immersive Information Mining is imperative to facilitate knowledge discovery. The primary usage of the proposed Immersive Virtual Reality System (IVRS) will consist of research, teaching and training, design and development of the new products for industry in the domain of digital visualization, practical problem solving for the society and immersive experience. These are further described below:

1.1 Research

Some of the broad research applications are illustrated below:

Understanding the road user behaviour and interaction with traffic: As per the WHO, road accidents are the 8th leading cause of death and expected to be the 5th leading cause of death by 2030 worldwide (Urie et al., 2016). Moreover, according to the Ministry of Road Transport and Highways data, about 1,50,000 people die due to road accidents in India. The WHO indicates that despite India holding less than 1% of world's vehicles, it accounts for 6% world road accidents. Road user behavior is one of the predominant factors for road accidents. The road users include primarily drivers and pedestrians; and their potential interaction with the traffic stream needs to be monitored in order to minimize the crash probabilities. However, examining how the road users behave at different traffic facilities (example, pedestrian crossing at unsignalised intersections, mid-block sections, etc.) and with different vehicle composition using traditional data collection approaches in the field conditions is unsafe. With the intrusion of IVRS, it will be easier to monitor and evaluate the behavioural characteristics of road users, which will aid in highlighting the limitations of existing road safety standards and improving the road safety enforcement policies.

Traffic infrastructure evaluation and development: It is important to conduct periodic assessments of existing traffic infrastructure and to suggest the development of new transportation facilities (e.g., new traffic interchange, pedestrian crossing facility) in case the existing infrastructure completes its service life or in case of unprecedented natural and biological disaster (such as COVID-19, SARS, contagious diseases). IVRS provides a platform where the operational traffic facilities can be evaluated and quality improvements and planning interventions can be applied. Further, the limitations in traffic management approaches can be highlighted and the traffic-related issues can be resolved. The facility will enable IITB to collaborate with various Government Organizations for conducting safety audit and evaluation of a variety of transportation infrastructure projects.

Construction safety and worker behaviour in terms of reacting to hazardous situations: The proposed IVRS would provide an enhanced testing field in the areas of use of Building information modelling in planning and design, construction safety and design iteration. The implications in the area of construction safety and worker behaviour on construction sites where otherwise difficult and hazardous situations can be simulated would provide an increased understanding on the efficacy of the safety process and thus help research immensely. The worker behaviour in terms of reacting to hazardous situations (including biological disasters like COVID-19) can also be modelled in this environment. The IVRS environment also gives ample opportunity for research into the ergonomics of various jobs in construction and also understanding the impact of some interventions in this area.

Structural inspection of distressed highway bridges: One of the research applications of the proposed Immersive Virtual Reality System (IVRS) will be to conduct structural inspection of distressed highway bridges using virtual reality, wherein high-resolution 2D images can be integrated into life-like 3D renditions. Such facilities are in existence in some universities [for instance, see Jáuregui et al. (2005)] resulting in substantial benefit to the academia and industry likewise. Highway bridge condition rating constitutes an essential part of research on bridge engineering, wherein the ratings are often used to derive service life-prediction models, deterioration models, choosing advanced structural health monitoring systems, and even computing the value of information from life-cycle cost perspectives. Existing research work on this topic within the structural engineering research group of civil engineering (for example, see Khan et al. (2018)] still relies on subjective bridge rating systems.

Bridge resilience estimation aided by virtual data realization: The virtual reality environment of CAVE can be implemented in and integrated with traditional structural analysis and performance assessment of bridges. The present state-of-the-art risk and resilience assessment of bridges and transportation networks rely heavily on component- and system-level analyses. Such traditional analyses often fall sort of capturing spatial distribution and propagation of performance variables in a correlated manner. Embedding a bridge model in a virtual reality platform will enable (i) visualization of interaction between the regular and extreme loading scenarios, and (ii) identification of strongly correlated parameters that are responsible for propagating distress conditions from one to another component of a bridge and from one to another stage of a bridge's life. Another promising application of a virtual reality platform will be to identify the spatial and transient propagations of perturbation, caused by bridge damage, to a highway corridor. A model for such propagation will enable quick visualization and realization of traffic data that can be successfully integrated with the estimation of risk and resilience of bridges and a highway transportation network under urban setting. Such generated data will be extremely beneficial in augmenting real-life data, which are not often easily available. Once implemented, CAVE enthused risk and resilience estimation framework has the potential to take a leading role in planning, designing and maintaining smart urban civil and transportation system infrastructure.

Urban design and safety perceptions: One of the major interests is to study the perception of urban physical environment. In this regard, it is required to conduct several experimental approaches through live participation. However, this becomes increasingly difficult to get participants to travel to different locations for these studies. The said technology with the required accessories would

enhance such kinds of studies to a great extent. These studies would have positive implications in terms of urban design and planning, safety perceptions, gender related research and enhanced capability to simulate a scenario for various urban and related research.

Data mining and exploration in Environmental studies: The exponentially increasing amount of Earth Observation (EO) data requires innovative approaches for data mining and exploration. This system may be applied to high-dimensional data to map into a lower-dimensional space to be visualized in an immersive 3D virtual environment. In such a system, users can navigate within the "data volume" to get the visual perception. Moreover, one can manipulate the data and provide feedback for other processing steps to improve the performance of the data mining system. In general, data mining (i.e. Immersive Information Mining) proposes an innovative processing pipeline comprising feature extraction, dimension reduction and immersive visualization and interaction. This process operates in parallel to the principal process pipeline (feature extraction and machine learning) to provide users with a mechanism to give feedback to other processing steps.

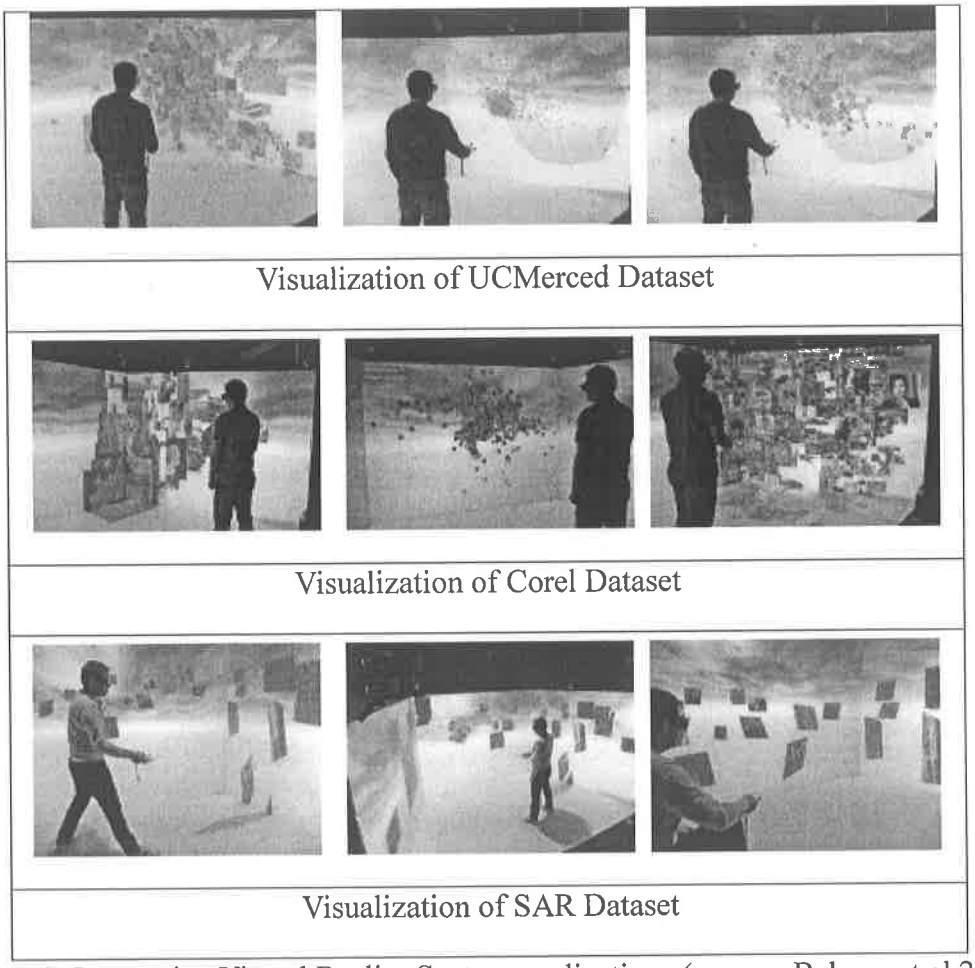

Figure 1: Immersive Virtual Reality System applications (source: Babaee et al 2013)

1.2 Design and Product development:

Cloud-network-based tool for a digital persona: Using advances and proliferation of inexpensive continuously synced Wearable-Sensors, and Machine Learning (Artificial Intelligence) computational technology, we propose development of a powerful cloud-network-based tool for a digital persona: for widespread effective implementation (and monitoring of effects) of the following:

(a) A personalized pulse-of-the-student-reading remote learning program & work-portfolio management as a replacement for traditional school/college education;

(b) A health and wellbeing predictive and prescriptive digital companion;

(c) A personal communication and a social networking tool that allows intimate emotional connect between participants (feeding on wearable sensor data) that aims to meet/exceed face-to-face interaction bonhomie; and

(d) A human-machine IOT-based symbiotic continuously-cross-learning system for optimal performance for remote or local operation, and for predicting & preventing human or machine caused excursions/accidents.

It is proposed to develop a digital twin model of every participant, one that learns and understands the psycho-physio-intellectual persona of the individual, and nudges it along a thriving path guided by a personalized AI guru deriving from the composite wisdom of experts, current and past; and/or weaves the strands of individual virtual persona into a hive-super-organism displaying super-intelligence or Artificial General Intelligence (AGI). This digital twin is best visualized, operates and interacts with other similar individual digital-twins in an AR/VR environment.

Design and development of new products (in the domain of mobility and vehicle design): Vehicle design process is highly capital intensive. Industry and academia all over the world use many state-of-art digital tools to ensure cost effectiveness and efficiency in design and development of the new products. The longer development cycle and associated costs of development of prototype development are reduced sharply by deployment of cutting-edge immersive visualization technologies such as VR/AR/MR. Many leading OEMs in India have basic visualization setups but do not have immersive experience labs. IIT Bombay has an opportunity to be a pioneer in leading the research and practical problem solving in digital visualization, usability studies and immersive experience in the domain of mobility and vehicle design. The proposed IVRC facility will primarily be used for industry linked projects and research activities as described below:

1. Design projects
    (a) Offering design expertise to Industries (OEMs, MSME) in presenting high end visualisation, conducting usability and aesthetic evaluation studies for interior and exterior designs for vehicles ranging from personal transport vehicles to public to commercial vehicles.

    (b) Simulator and AR/VR augmented interface design projects for Ministry of Railways, Transport (Road, Waterways) and Civil aviation

    (c) Mobility projects with Ministry of Tourism, Culture, etc., e.g., Mobile virtual tours etc.

2. Research and development

    (a) Role of VR/AR/MR as an effective design learning tool

    (b) Role of VR/AR/MR as an effective tool for industry especially in a new product

development cycle

(c) Role of VR/AR/MR as an effective and efficient design thinking tool

1.3 Teaching and Training:

The proposed Immersive Virtual Reality System (IVRS) will be of immense help for teaching Civil Engineering (e.g., Transportation Engineering, structural engineering and construction management) courses for students. Through experience, it may be argued that students grasp the subject matter best when coupled with practical experience. While site visits help in such matter, frequent visits demonstrating course content that spans a semester may be hard to arrange. This is wherein the proposed IVRS system will help, such that regular student visits to the facility can be made as and when required to demonstrate the practical aspects of Civil Engineering. Easy examples can be the visualization of reinforcement layout at different stages of construction and Traffic flow on a typical interchange. Further, The IVRS would be a great addition to evaluate the BIM models developed by students as part of their coursework and projects in the area of construction technology and management. Real-time rendering is made possible in a CAVE environment which helps the students appreciate the intricacies and the impacts of modelling involved. IVRS could become part of the Urban Design and Engineering laboratory in CUSE as a module. The proposed IVRS can be useful for Teaching courses and student projects in IDC as described below: (a) Augmentation of skills in currently offered VR courses through IVRC; (b) Proposition to float next generation a) ideation courses through sketching in 3D VR space b) Form and aesthetics courses; and (c) Making students industry ready through high-end immersive visualizations in their BDes/MDes projects.

The IVRS environment can also be leveraged to help industry in training and advisory purposes. The training of industry professionals on BIM and also in terms of uses of BIM like Clash Detection can be achieved through CAVE technology. Father, the assimilated 3D renditions can be readily used for training highway bridge engineers, stakeholders, and decision makers to develop a unified rating system regarding the structural condition of critical bridge components, such as columns, bearings, abutments, bridge superstructure, among others. At present, there exists significant amount of human-dependent subjectivity that may lead to disparity in the rating system (Aktan et al. 1996). Consequently, through adequate training, such inconsistencies in the rating system may be removed. Therefore, the proposed facility would have implications in terms of research, design and product development and teaching/training specifically.

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