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A Journey into Space-tial Computing: Trials and Tribulations of an Episodic AR Ballet

Genevieve Smith-Nunes[1] and Alex Shaw[2]

[1] University of Cambridge, Cambridge, UK
[2] Glastonbridge Software, Edinburgh, Scotland
ges52@cantab.ac.uk

Abstract. A practical exploration of the immersive learning potential of developing a spatial computing and augmented reality (AR) episodic ballet experience. Discusses the challenges of translating industry development tools and practices to the computing classroom. Despite challenges in software tool choices and motion capture accuracy, the article envisions a future where immersive learning transcends traditional boundaries. It emphasises the crucial role of digital/data ethics education in computing and immersive education through biometric data and creative coding. This immersive learning journey's interdisciplinary fusion of technologies promises a transformative educational experience beyond conventional limits in the arts and classrooms.

Keywords: AR, biometrics, creative computing education, teacher training, ethics.

1 Introduction

Imagine a technology that can capture the real world in three dimensions, allowing you to interact and immerse yourself digitally in a storytelling environment. In the development of augmented reality (AR) ballet performances, spatial computing plays a critical role in the creative production of an augmented reality experience. This technology employs sensors and deep learning algorithms to abstract moving avatars of the dancers from the physical space of the ballet performance. This understanding allows for the seamless integration of digital elements, enabling them to interact and respond dynamically to the real-world environment. Through this process, the boundaries between the physical and digital worlds blur, creating a richly immersive and captivating experience for the dancers and the audience. This paper discusses the challenges of this development translated to the secondary computing classroom in a Trainee Computing secondary context.

The study and subsequent workshops followed an iterative approach using a blend of Agile and Design-Based Research methodologies. A mixed method data analysis using surveys, interviews, voice & chat from workshops data, then analysed each iteration using natural language procession (NLP) and Interpretative Phenomenological Analysis (IPA) approaches [1].

1.1 Through Space and Time

The AR experience will be delivered through an episodic short-form series suitable for a classroom context while embracing a format familiar to anyone consuming media in today's society [2]. Throughout the performance, the challenges of time delays, system glitches, and continuous monitoring of the astronaut are portrayed across five augmented reality (AR) episodes, each lasting approximately five minutes. The series finale concludes with a loss of signal, leaving the audience with the creative task of envisioning the resolution. Each episode focuses on a different computing theory or concept from a secondary computing perspective. The storyline of the AR experience gave the trainee teachers context for both the technical and ethical aspects of the project that could be translated and mapped to current computing curricula.

Space-tial, as used in the title, is a play on the theme of the AR experience and the new focus within XR of spatial computing. Augmented Reality worlds are the best-known examples of spatial computing, from Pokémon Go to Apple's Vision Pro. The digital storytelling of the AR ballet experience intertwines the realms of humanity, digital, and technology. It is a platform to contemplate the uncertainties of our future, fostering ethical discussions for both audience and classroom settings.

2 The Development Journey

Episodic development of the AR performance includes all stakeholder perspectives (dancer, developer, designer, educator, and researcher) and offers a collaborative approach to reimagining traditional performance through an immersive lens. Focusing on classical ballet creates space in the classroom for the Arts through technology and data interaction. Conceptually rich projects such as this are commonly employed within the secondary computing classroom, and the combination of complementary concepts opens the opportunity to explore digital art, data analysis, data-ethics discourse, and the obvious computer studies opportunities, through creative computing.

In a classroom context, data is often presented in a spreadsheet or a graph and can be conceptually alienated from its source, in this case we are reinforcing that there is a human behind the data set. Using electroencephalogram (EEG, see Fig 1) or body movement data (biometrics) is often difficult for pre-university students to understand or conceptualise. However, if we present data gathered through EEG next to a data visualisation of the brain. This can be real-time or recorded video; we aim to make it easier to associate learning concepts with their foundations in scientific data. This is especially helpful in immersive learning, making lessons more interesting and interactive. Traditionally, graph data, such as EEG or body data, is not presented in a way that is easily understandable by humans. However, by visualising this data alongside a human representation, we can humanise the data and gain a deeper understanding of the information it represents.

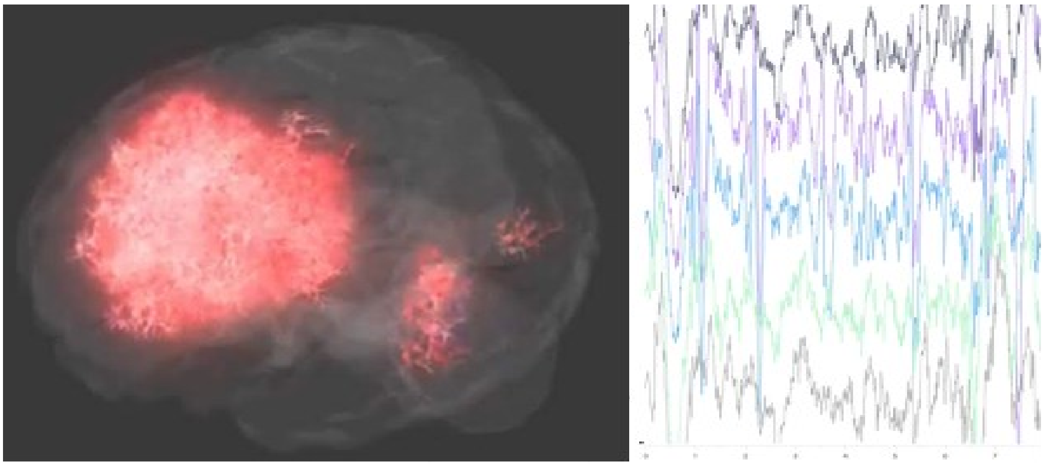

Fig. 1. EEG visualisation and graphing data recorded via EMOTIV software.

Through workshops with trainee secondary computing teachers (past and ongoing), explored/ing the different data representations proved to be a beneficial approach to immersive learning alongside computing curricular requirements, creating more engaging and interactive learning experiences. Figure 1 encapsulates the brainwaves and graphs data core to the development of the AR ballet. The trainee teachers found graphing less connected to humans than the data visualisation, and both were even demonstrated in real-time.

The project leverages Rokoko Vision [3]. This motion capture tool leverages Deep Neural Networks (DNNs) to translate this raw data into a refined and animated form. Functioning as a bridge between 2D RGB camera footage and animated poses, Rokoko Vision is a proprietary online service that converts 2D RGB camera footage to pose information in BioVision Hierarchy (BVH) format. BVH can be thought of as a 3D skeleton containing the movement data of our ballet dancers, and once in this format it is readily consumed by many industry-standard tools, such as Blender, to produce animated 3D models that replicate the dancer's motion. Unreal Engine [4], a proprietary 3D engine, is the final technical tool in production. It combines the animated 3D models into an immersive augmented reality world that runs on the audience member's mobile device.

2.1 The Development Trails

However, this journey is not without its challenges and considerations. While previous experiences with Unity [5] influenced the choice of MakeHuman, the team deliberated other choices such as Unreal Engine's Metahuman Creator, but MakeHuman's output quality was superior, at the time. Yet, this option posed the risk of increased dependence on non-open-source software. Additionally, Rokoko Vision, although a potent tool, is not without limitations. Challenges such as inaccuracies in processing fast movements, occlusions, and nuances like toe-pointing (ballet shoes) underscore the need for ongoing refinement to faithfully capture the full spectrum of baller dance movements. In addition to requiring high-end technological specifications in order for the software to run.

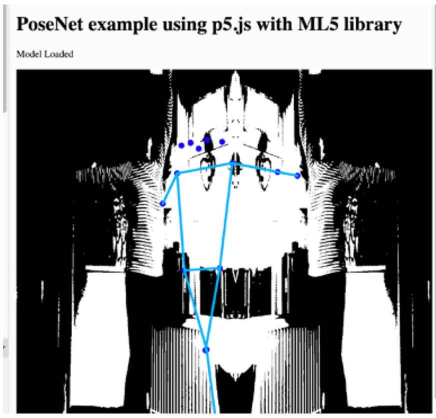

Fig 2. Motion capture and video join data.

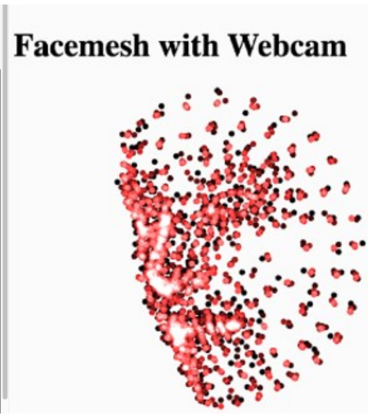

Fig 3. p5.js face mesh without video.

2.2 Translation to the Computing Classroom

For classroom use, the programming languages and platforms were changed to P5.js with ML5 [6] for use with educators and students who are not proficient in C#. The purposeful selection of JavaScript and web languages meant educators could access and tinker with the tools. However, they could not create the 3D models required for the AR episodic ballet. The development was separated into the following coding activities [7]: motion capture (fig 2), facial tracking (fig 3), and sound levels. Additionally, Python and Sonic Pi programming activities to generate music using the EEG aggregate datasets. For 3D model development, we used Blender, a new tool for many trainee teachers. Therefore, this was less of an immersive data exploration than a learning curve for a new tool.

The translated classroom activities encompassed a variety of cutting-edge technologies and software tools to enhance the learning experience and engage trainee teachers and their students in hands-on projects. One of the activities involved facial mapping and full body tracking using p5.js, as depicted in Figures 2 and 3. P5.js is a JavaScript library that allows for creative coding and interactive graphics, making it an excellent tool for exploring motion and visual representations. Another activity focused on 3D modelling using Blender™, a powerful open-source software for creating animated films, visual effects, art, 3D printed models, and more. Students had the opportunity to design and manipulate 3D models, gaining practical skills in digital design and visualisation.

Additionally, trainee teachers explored augmented reality (AR) development using Adobe Aero, a platform that enables the creation of interactive AR experiences. Delivered both through iPad and Smartphone as the screen real-estate is larger with iPad or tablet devices [8]. This activity used biometric data such as motion capture and brainwave electroencephalogram (EEG) datasets to develop immersive and responsive AR applications. These applications allowed for experimentation with integrating real-world data into virtual environments, enhancing their understanding of AR technology and its potential application in their own classrooms, such as galleries or online showcases [9]. Throughout these activities, the selection of tools and technologies was carefully aligned with the computing classroom's programming proficiency and network access limitations. This ensured effective engage with the material while considering practical constraints and available resources.

Alongside learning programming and computing content, the activities also encourage discussion amongst the trainee teachers about the ethical implications and privacy concerns related to biometric and tracking technologies and data. These discussions encouraged participants to reflect on the ethical implications of collecting, storing, and using personal data in digital projects. The facial mapping code and discussion on tracking, surveillance, and biometrics led trainee teachers to explore the ethical implications alongside technical activities. By integrating data ethics discussions into the curriculum, the classroom aimed to develop students' critical thinking skills and ethical awareness, preparing them to navigate the complex landscape of technology responsibly and conscientiously.

Augmented Reality (AR) development is a classroom-friendly alternative to Virtual Reality (VR) in educational settings, requiring fewer external resources and potentially reducing classroom expenditures, while encouraging open experiences that can be shared trivially between students and teachers. This affordability facilitates an immersive exploration of technology within the classroom, encompassing a comprehensive project that delves into digital storytelling, self-expression, manipulation of extensive datasets, and the critical examination of data ethics. Notably, the ethical considerations surrounding data are potentially an emerging domain in training new computing secondary teachers in England.

In addressing classroom challenges, a straightforward yet significant obstacle arises from the prohibition of devices in educational settings, hindering the development of AR experiences [10]. Contrarily, the UNESCO 2023 report [11] on technology in education advocates for a 'human-centred vision' regarding the judicious use of technology in classrooms rather than endorsing a blanket ban. This report highlights concerns such as data breaches, misuse, and unregulated utilisation, emphasising the necessity for proper oversight and governance.

The essence of our project extends beyond merely facilitating an AR ballet experience or providing educational resources. At its core, it embodies a holistic commitment to this human-centred vision, addressing the broader ethical challenges of biometric data and opportunities presented by immersive technologies in education.

3 Future Tribulations

In the evolving landscape of computing and immersive education, there has been a notable rise in the significance of digital humanities, immersive technologies, and the imperative need for digital and data ethics education. As these areas continue to gain prominence, designing classroom experiences that delve into the multifaceted aspects of immersive biometric-driven experiences becomes increasingly crucial.

Exploring these experiences allows us to engage with the creative, technological, and ethical dimensions they present. Creatively, they offer a new realm of possibilities, merging artistic expression with technological innovation. Technologically, they challenge us to push the boundaries of what is possible, requiring a deep understanding of both hardware and software integration. Ethically, they raise important questions about data privacy, consent, and the responsible use of biometric data, emphasising the need for comprehensive digital and data-ethics education.

Moreover, navigating these considerations calls for an interdisciplinary approach that fuses various technologies, methodologies, and fields of study. This interdisciplinary fusion enriches our understanding and paves the way for a more holistic and immersive learning experience. Such an experience has the potential to transcend the confines of traditional ballet and conventional classrooms, offering students and educators alike a transformative journey that integrates technology, art, and ethics. By embracing this interdisciplinary approach, we can foster an innovative, inclusive, and ethically grounded learning environment, preparing students to be future-ready in an increasingly digital and interconnected world.

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