Motion Capture Using the Internet of Things Technology: A Tutorial

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ABSTRACT

This tutorial explores a variety of applications for Internet of Things (IoT) aided motion capture, drawing comparisons from different technologies and implementations. Various uses for these implementations will be discussed, as well as weighted against one another to analyse their advantages and disadvantages.

CCS CONCEPTS

•**Hardware → Sensor applications and deployments; Sensor devices and platforms; Wireless integrated network sensors;**

KEYWORDS

Internet of Things, Smart Suite, Motion Capture, Wearable Body Technology

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1 INTRODUCTION

The Internet of Things (IoT), is a concept that proposes the Internet connectivity of everyday objects. These objects can be anything from household appliances, such as a fridge, to more top level applications, such as a home's heating system. The intended benefit of such an ecosystem is a more connected world, and in commercial terms, an easier and more manageable lifestyle for its users. The ideal being that a consumer can control most of their household objects from, for example, their smartphone, anywhere in the world, providing they have Internet connectivity.

Many IoT applications are human-centered, such as body monitoring where wearables are used for sensing physiological and behavioral data. This paper will explore the use of IoT wearable body technology for posture capture applications. Posture capture technology has multiple implementations, anything from medical MRI use, to film and TV, and animated graphics. There are a variety of technologies currently in place, that use posture capture technologies to track a user's movement in greater detail, as well as log this information for further analysis. An example of a more everyday implementation of posture capture technologies is products such as the Nintendo Wii or Microsoft Xbox Kinect.

The remainder of the paper is organized as follows: Section 2 gives the common motion capture applications. Section 3 explore the current research in Motion Capture Technology (MCT). Section 4 concludes the paper.

2 MOTION CAPTURE APPLICATIONS

There exists a variety of motion capture applications that are used within industries, which utilise both MCT and IoT. This section presents a selection of these applications.

For decades, computer animated films have used motion capture 'suits' to represent life like character movement in a variety of films. A well-known example of such a film is 'Avatar'. This film was heavily dependent on the tracking of actor movement, as in-film, many characters are digitally animated. Actors in this film wear specially designed suits, housing an array of sensors, each of which represents a specific point of focus such as part of a limb. When the actor moves, the suit will sense this movement and interpret it through specially developed software, synchronising it to the digitally animated model used in the film.

Motion capture is also used for motion analysis, primarily in sporting applications such as golf. Usually found in golf club training areas, players can attach sensors to their golf club, upper arm, and leaning leg. These sensors then monitor a variety of variables from the user's swing, such as force, arm extension, and degree of swing. The data is then synchronised with the in-house analysis system, which can provide the user with in-depth and accurate information about their technique, as well as where they lacked and how to improve.

Virtual Reality (VR) also takes advantage of MCT by increasing the degree of which it can submerge its user into the state of VR. Allowing the user to interact with the virtual world, can only be achieved by taking readings from the user's current stature, and adapting the virtual reality space to accommodate for this. Once the virtual reality environment is built, per data retrieved from its user, it can then begin to map user movement inside the space, thus giving the illusion of interaction.

Recently, motion capture has become very popular for medical applications. Medical research is constantly looking for ways it can extract more information from patients, and MCT is just one way in which a patient's physical readings can be expanded. A benefit of combining IoT with MCT is that there is the potential of removing the need for patients to travel to check-up centres and consult with a GP directly. Ideally, the system could become so industrialised, that it finds a way into the consumer grade market, thus allowing a patient to wear a movement tracking node during their daily activities that sends readings to their GP. Software could then be designed to notify the GP should an emergency state be reached and speed up the process of an emergency response.

3 CURRENT RESEARCH

Research is currently being carried out for each of the application domains reviewed in Section 2, as well as a variety of others. Researchers and practitioners tend to deal with the two subjects separately, MCT or IoT. The depth of research is usually permitted by the application in question. Certain applications do not require detailed user movement data for their analysis, and as a result only broad movement is tracked. Other applications require much more intricate detail and allow research to be more in-depth.

This wide body of literature in the motion capture field of study can be dissected into three main components of focus/application: medical, motion analysis, and VR. Different sectors take interest in each area of research. The medical sector has most of its research investment set aside by government, or large privately owned health care organisations. The privately-owned organisations are looking for a way to create a product so useful that they can go on to retail it to national health care services. Government, meanwhile, has an interest in creating these products themselves and thus excluding the middleman of private health care organisations.

Research into VR is more likely to be backed by privately owned companies specialising in selling VR solutions to businesses, usually as marketing tools. An example of such technology is Audi's new VR showrooms [6], which were first premiered at the Consumer Electronics Show (CES) 2016. The technology in this VR headset allows potential customers to immerse themselves in a virtual space where they can find and interact with their desired Audi car. Once inside this environment, the space will adapt in real-time to the capture of the human's movement, simulating the illusion of the car in physical space.

Motion analysis is a multidisciplinary field, which attracted investment from various industries. An example of such application is the use of motion capture on horses [2]. Equine veterinarians often use motion tracking to detect performance defects in racing horses. The data captured from these motion analysis tests can reveal abnormalities,such as growth impediments in one of the horse's legs. Such intricate information is highly desirable to competitive owners, and therefore can be retailed at a high price in order to subsidise the cost of research.

As the applications above show, regardless of research area MCT is largely used to build a model of what is deemed 'regular' movement. New data can then be compared to this model in order to detect abnormalities. The motion capture can be so precise that even minute digressions from regular movement can be flagged as an early stage of abnormality, thus allowing analysts to look into this further and monitor its deterioration. The main benefit of this, is research can then be conducted on the abnormality itself, allowing a prevention technique to be developed and applied to any future cases of this abnormality when the onset is detected.

4 CONCLUSIONS

MCT and wearable IoT technologies display unique benefits and drawbacks. It can not be overlooked that IoT is considerably more cost effective than other market solutions, such as just one of the many purpose-built MCT solutions. However, it is also clear that MCT requires significantly less development, and is generally better supported out of the box, suitable for mission-critical applications such as medical diagnostics.

Wearable IoT provides a fully bespoke solution, which generally incurs a higher level of future customisation and a more tailored fit into the application [1, 3, 7]. Due to the product being built from the ground up to the exact specification of the application, the product will also be lighter, as it will contain only necessary functionality [4, 5]. This will aid the ability to roll the solution out across a wider platform. MCT offers a more precise set of readings, which is crucial in finding minute symptoms of any potential onset. This approach, and other purpose-built solutions, provide greater accuracy at a higher cost.

In conclusion, there is a strong motivation to develop a more cost-effective and widely usable sensory network solution for motion capture and analysis. This solution can be used in a variety of different applications, and due to the fact that it is a custom solution, each application would be a fully bespoke system, thus allowing full integration with any existing processes. The fact that this implementation is more cost effective makes it accessible to a variety of new industries, with the potential for new developments to be explored.

REFERENCES

[1] Abdelrahman Abuarqoub, Mohammad Hammoudeh, Bamidele Adebisi, Sohail Jabbar, Ahcne Bounceur, and Hashem Al-Bashar. 2017. Dynamic clustering and management of mobile wireless sensor networks. *Computer Networks* 117 (2017), 62 – 75. DOI:http://dx.doi.org/https://doi.org/10.1016/j.comnet.2017.02.001 Cyber-physical systems and context-aware sensing and computing.

[2] Yasmin Ali. 2015. Motion capture improves animation of animals. http://www.bbc.co.uk/news/science- environment- 34175225. (2015). [Online; accessed 8-June-2017].

[3] Sohail Jabbar, Murad Khan, Bhagya Nathali Silva, and Kijun Han. 2016. A REST-based industrial web of things' framework for smart warehousing. *The Journal of Supercomputing* (2016), 1–15. DOI:http://dx.doi.org/10.1007/s11227- 016- 1937- y

[4] Sohail Jabbar, Abid Ali Minhas, Moneeb Gohar, Anand Paul, and Seungmin Rho. 2015. E-MCDA: Extended-Multilayer Cluster Designing Algorithm for Network Lifetime Improvement of Homogenous Wireless Sensor Networks. *International Journal of Distributed Sensor Networks* 11, 9 (2015), 902581. DOI:http://dx.doi.org/10.1155/2015/902581

[5] Sohail Jabbar, Farhan Ullah, Shehzad Khalid, Murad Khan, and Kijun Han. 2017. Semantic interoperability in heterogeneous iot infrastructure for healthcare. *Wireless Communications and Mobile Computing* 2017 (2017).

[6] Paul James. 2016. Hands On: Audi's Stunning Next-gen Showrooms are Powered by Vive and Rift. http://www.roadtovr.com/audi-virtual-reality-car-showroom- htc- vive- pre- oculus- rift- cv1/. (2016). [Online; accessed 12-June-2017].

[7] Murad Khan, Sadia Din, Sohail Jabbar, Moneeb Gohar, Hemant Ghayvat, and S.C. Mukhopadhyay. 2016. Context-aware low power intelligent SmartHome based on the Internet of things. *Computers & Electrical Engineering* 52 (2016), 208 – 222. DOI:http://dx.doi.org/10.1016/j.compeleceng.2016.04.014