Motion Capture Technology and leading Biomechanist Dr Hannah Jarvis

Motion capture or MoCap is a rapidly evolving technology that records and analyses human movement in real-time. MoCap creates digital models allowing the mind-blowing animations and simulations of the human form famously used in the gaming, film and virtual reality spaces. From the array of skins in Fortnite to the creation of Gollum/Smeagol in Lord of the Rings motion capture creates digital magic. However, it is not only for entertainment, the technology has also transformed performance analysis in sport, and diagnosis and rehabilitation in the clinical sector.

Thanks to artificial intelligence, platforms are available which use two dimensional (2D) recorded videos, or live phone/webcam streams to turn the human subject into a 3D digital character. This has made MoCap cheap, simple and accessible. However, as yet, they lack the precision required for performance or clinical assessment and research.

At its core MoCap measures **joint kinematics** – skeletal movement without reference to the forces involved. It provides valuable data on **displacement**, **velocity**, and **acceleration** in multiple planes of motion offering a detailed picture of linear and angular movement. High quality MoCap technology involves a multi-camera set-up, either on portable tripods or fixed within a specific environment, to capture skeletal movement in 3D hundreds of times per second from all angles. Known as optical MoCap, universities, performance institutes, private companies and hospitals around the world have this technology at their fingertips to use in research, diagnostics and performance optimisation – they can even be installed underwater!

Optical MoCap can use two main tracking systems: marker-based or markerless technology to track and digitise human movement.

- Marker-based systems require the precise placement of markers on anatomical landmarks which minimise the influence of soft tissue and track skeletal movement. It is the gold standard for accuracy and reliability and widely used in research and clinical settings. However, the placement of markers is time-consuming.
- Markerless systems rely on video cameras to video track movement and AI driven algorithms are used to identify the shape and location of anatomical structures to build a virtual skeleton. Although the set-up time is reduced the accuracy is partially compromised, however with rapid advancement this is likely to be the future of gait (walking) analysis.

To enhance the opportunity MoCap holds there are bolt on systems which integrate with MoCap systems to maximise the volume and quality of the data collected. These

include equipment to not only assess joint kinematics but add the assessment of joint kinetics (the forces that cause movement) too. These include;

- Electromyography (EMG) – EMG measures muscle activation patterns during movement providing a more complete picture.
- Force plates – measure ground reaction forces (GRF) which provides the size and direction of forces acting on the performer or patient. The size of the force and time the force is applied can be displayed in the 3 dimensions at the same time as the MoCap system tracks movement.

Dr Hannah Jarvis is a Clinical Biomechanist who conducts research at Lancaster Medical School and lectures on the Sports and Exercise Science degree programme. A biomechanist is a professional who specialises in the study of human mechanics – how forces affect movement and performance. Dr Sarah Powell popped along for a chat:

1. How did you become a biomechanist?

"*I am fascinated by how the human body moves when we walk, run, jump and move. After my degree in Podiatry I studied for my PhD in foot and ankle biomechanics - I was lucky enough to work with one of the greatest foot and ankle biomechanists Professor Chris Nester. Since then, I have worked on and led a series of research projects focused on how the bones in our bodies move in health, disease and injury.*"

2. What is the best thing about your role?

"*I love my job! The combination of teaching, research and engagement is challenging but brilliant. I really like teaching and supporting students. Seeing them develop knowledge and skills in biomechanics, to becoming accomplished researchers through their own studies is very special. My research has helped us better understand how a disease or injury affects the ability to walk or demonstrate the importance of rehabilitation. Making a difference and improving care is a real driver for me and my research team. I also really enjoy working with industry, we have some really exciting on-going research projects testing new products so getting to see them and test them before they go to market is really interesting*."

3. Tell us about one of your research projects and the impact it will have.

"*One of my research projects I'm most proud of is a project I led in collaboration with the Ministry of Defence during the wars in Afghanistan and Iraq. It redefined our understanding of what is possible with investment in rehabilitation in military personnel who had sustained traumatic* ***amputation*** *(loss of a limb). More recently I have secured a series of research grants which have, and will continue to explore how a* ***stroke*** *affects* gait (walking). In one study in 2019 I found only 23% of stroke survivors returned to work and one of their key reasons for not going back was experiencing difficulties with walking. *This research continues and will help us develop better and more research*

informed rehabilitation for stroke survivors. If we can improve stroke survivors' ability to walk, they will not only go back to work but have a better quality of life."

4. What has been the most exciting use of the motion capture system at Lancaster University so far?

"*I could talk to you all day about how great 3D motion capture is, but recent developments in markerless tracking have the potential to revolutionise gait and biomechanical assessment. It is a lot faster and easier to use, but we as the biomechanics community need to ensure it is still accurate for decision making in clinical practice*."

5. What do you do in your spare time?

"*I love cycling and compete to National standard. Previously, I competed in mountain running to international level and have represented Wales 21 times, but sadly a foot injury means I am now unable to run. However, cycling has become a new love of mine and a new challenge. I cycle to work most days in all weathers (rain, freezing cold, in the dark or sunshine) which is a 52km round trip. It is a great way to reflect on the day and think of new activities for teaching or research projects. I have thought up many grant proposals while cycling in the dark on the way home! I recently finished 3rd at the British Gravel Championships in the vet40-44. This was an accumulation of a lot of learning (how to cycle fast off road), developing my physiological capacity (from running for 3hours to cycling for 5+hours) and hard work. I thought my sporting career was over after my foot injury, but I have really enjoyed learning a new sport and excited to see how far I can go with it*."

6. How has biomechanics helped you as a performer?

"*It has helped me better understand my body by diagnosing injuries, knowing when I should rest and helped me further my training methods. However, probably the best thing is having a different perspective on work. Most of the people I work with in my research are unable to or have great difficulty walking so it places everything in context and drives me to do better and bolder research*."

Find out more about Dr Hannah Jarvis: Hannah Jarvis - Lancaster University

Key Terms:
Joint kinematics: analysis of the movement and mechanics of joints without reference to the forces involved
Joint kinetics: analysis of the forces that cause movement
Displacement: the shortest straight-line route from start to end positions (m)
Velocity: the rate of change in displacement (m/s) – displacement/time
Acceleration: the rate of change in velocity (m/s/s) - (final-initial velocity)/time
Stroke: a reduction or interruption of blood flow to the brain which leads to brain cell damage
Amputation: Loss or removal of a limb either through traumatic, congenital (born without) or due to surgery

Want to know more?
See how markerless motion capture can be used at the Human Biomechanics Laboratory at Lancaster University: In The Lab: Markerless Motion Capture at Lancaster University
Find out about how one manufacturer of motion capture systems is used in sports performance and analysis: Motion Capture for Sports Performance & Analysis | Qualisys | Qualisys

Have a look at the methods used and data collected in a research study: Return to Employment After Stroke in Young Adults | Stroke Find out more about what a stroke is, its effects and support available with the Stroke Association: Stroke Association | Strength through support
Exam Board Links: OCR: 1.3.a. Biomechanical principles, levers and the use of technology: analysing movement through technology AQA: 3.2.4.8 The role of technology in physical activity and sport: understanding of technology for sports analytics
Dr Sarah Powell is a senior lecturer in Sports and Exercise Science at Lancaster Medical School, accredited sports and exercise scientist and author of a range of A-level PE textbooks.