Digital avatars: Useful helpers in the forest and beyond

The American film Avatar brought a whole new experience to the big screen – in large part thanks to the pioneering use of motion capture technology. The filmmakers realistically captured the actors' performances and transferred them into digital avatars. Experts from the Department of Engineering of the MENDELU Faculty of Forestry and Wood Technology use similar digital avatar technology to analyse workplace physical strain and ergonomic movement and to predict risks associated with how people and dogs move their bodies.

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PHOTO: AVC MENDELU

The history of wearable technology reaches back to the 1970s, when it began to be applied in medicine, aviation, and the space industry. The low quality of sensors and limited computing capabilities prevented its widespread use. But today things have changed. Not only is monitoring heart and respiratory rates, body temperature, skin conductance, brain activity, and other bodily parameters commonplace, but thanks to special sensors that monitor the position and movement of body parts, it is also possible to record human body movements. This technology is known as motion capture (or mo-cap). The information gained from this can then be analysed by not only advanced computer systems using machine learning and artificial intelligence but also mobile phones.

Nothing gets by digital twin technology

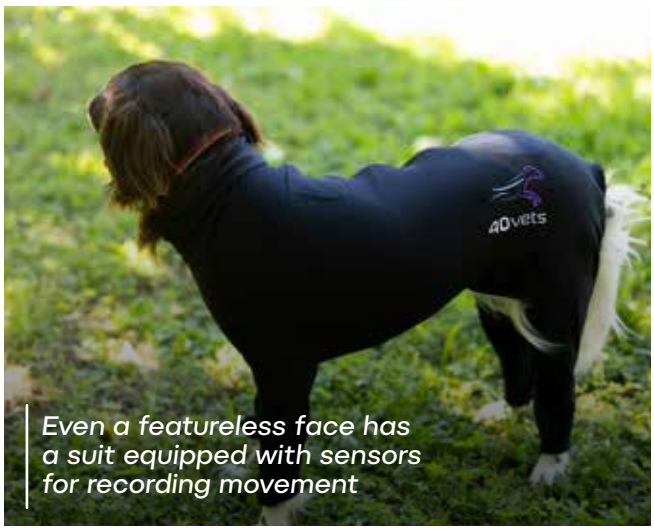
If you go running and you have on a smartwatch or are carrying a smartphone, when you're done you can see where you ran and how your heart performed. If someone went running with you and recorded you, you could also see a video of your run. But in a video you would only see the part of your body the camera was aimed at. Today's digital twin technology takes our motion tracking abilities even further! To collect information it uses an array of wearable sensors, which, like smartwatches, are placed on various body parts or even in clothing items. Today, your friend with a camera has been replaced by what are known as inertial measuring units (IMUs). "IMUs can, for example, determine the position of one of your soles while running and how fast it was moving right before it struck the ground wrong. Unlike a camera, an IMU sees everything, even if you were running in tall grass. Thanks to digital twins, you can gain information that would remain hidden if you were using standard recording technologies," says Martin Röhrich from the Department of Engineering, describing the capabilities of these sensors. "Since the beginning, we've been working with interrelated information about the spatial position of the body, the movements of the body and its parts, and the physiology of the person being studied. By combining all these data, we get a complex picture of the body's current state and the strains on each body part. Real-time data processing can also warn about potential dangers or risks," he adds.

Digital twin technology provides experts with new opportunities in the fields of health protection, injury prevention, and preventive and predictive medicine, as well as in managing physically demanding work. It can also be used to study how climate change affects the workplace.

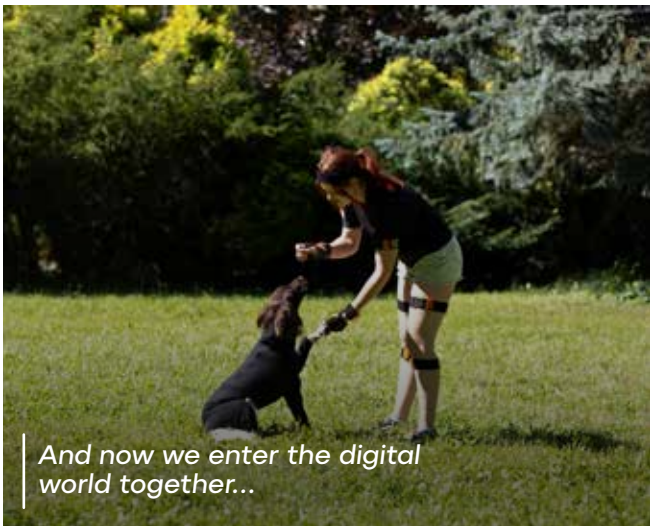
Show me how you walk, and I'll tell you what your musculoskeletal system has to say about it

The Department of Engineering mainly focuses on methods and technologies combining traditional notions of safety and health protection with ergonomics as a broad discipline covering all aspects of human activities. The findings that our researchers make are then applied in teaching and practice. This is why academic staff welcome the possibility to collaborate with leading technology companies and with researchers from other universities. They currently have the opportunity to try out systems for digitally recording workers' movements and for conducting ergonomic analyses of their movements during testing of newly developed forestry equipment.

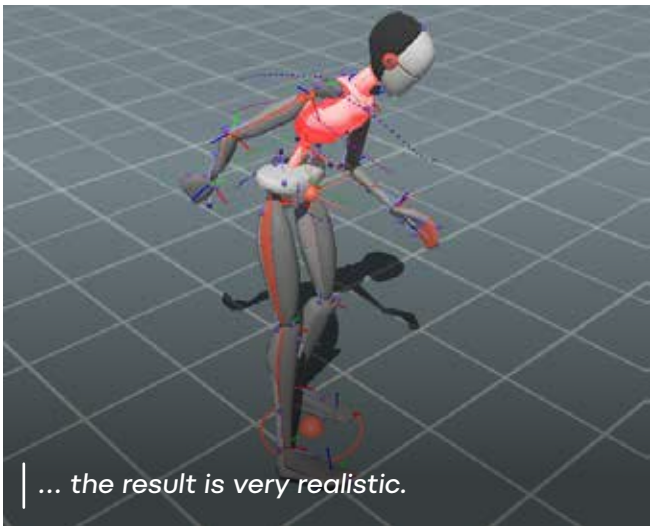
"Imagine you are a forester who has to cut down a tree, cut its branches off, measure the tree, mark it, and do many other jobs while walking on uneven terrain, bending over, turning around, kneeling, all while holding a chainsaw that weighs at least 10 kilogrammes. Using data from each sensor about the bodily dimensions of the operator and information about the object causing strain, in this case a chainsaw, we create a three-dimensional digital model that can assess how much stress is put on each joint, how much force is being applied to a certain part of the spine, or how to change walking patterns to improve long-term back pain. Moreover, we can combine this information with heartrate data, so we know how difficult each activity was for the forester. Based on this information, we can then propose changes to how he works, when and for how long he takes breaks, or we can suggest some injury prevention workouts to do before he develops chronic pain that tells



Even a featureless face has a suit equipped with sensors for recording movement


And now we enter the digital world together...


Installing the individual sensors and setting up the mo-cap system is simple...


... the result is very realistic.

him he should have been taking better care of himself," says Martin Röhrich, describing a model case. Experts from the Department of Engineering anticipate that by linking wearable devices with advanced software for analysing physiological data and ergonomic risks, they will be closer to creating digital human models to visualize how the body really moves at work. From there, it will be just another small step to developing predictive models and recommendations for optimizing working practices, designing workplaces, and reducing strain caused, for instance, by overloading the musculoskeletal system or by ever-increasing summer temperatures, which have an impact on increased fatigue and concentration.

The possibilities for using digital twins are practically unlimited, and they aren't just restricted to humans. "We're certain we can build on our previous collaboration with 4DVets, a Swiss company, and that we'll become part of a newly emerging international project focused on diagnosing gait issues and musculoskeletal problems in breeds of working dogs. We would be working with industry leaders. 4DVets is a world leader in predictive musculoskeletal diagnostics for dogs using wearable LupoGait® technology, which analyses gait," adds Röhrich, providing more information about this opportunity for international collaboration regarding digital twins. It can then be used for training working dogs and preventing injuries, and the findings can be incorporated into courses taught at the Faculty of Forestry and Wood Technology.

Smart technology is in the woods now

Modern technologies are transforming forestry equipment, even though forestry is often viewed as a traditional sector due to the manual labour involved.

"One of the most important innovations has been augmented and hybrid reality, which allow us to perform advanced data visualization in real time. Foresters can, for example, use special headsets to see information about trees in the field, which makes planning harvesting easier. Advanced harvesters and other harvesting machines equipped with modern navigation sensors and LIDAR scanners, technologies that use safe laser beams to measure exact distances and movement in real time, enable us to precisely identify forest stand structure and plan harvesting paths. This makes harvesting not only faster and more precise, but it is also more environmentally friendly because it minimizes damage to surrounding forested areas," says Eva Abramuszkinová Pavlíková from the Department of Engineering, naming some of the modern technologies used in forestry.