Chapter 10:

Wearable Technology – Activity Recognition

Overview

1 What is activity recognition and why is it useful?
2 Example of activity recognition in research
3 Example of activity recognition applied to out of laboratory contexts

[1] Photo by Bruno Nascimento on Unsplash

HAR - Human Activity recognition.

What is activity recognition and why is it useful?

Human activity recognition or HAR is the process of **interpreting human motion** using computer and machine vision technology. Human motion can be interpreted as activities, gestures, or behaviours which are recorded by sensors. The movement data is then translated into action commands for computers to execute and analyse human activity recognition code. [2]
The full potential of activity recognition has yet to be discovered. Still, it has proved useful in many different fields already, such as sports, training, security, entertainment, ambient-assisted living, and health monitoring. [2]
Activities that can be detected are:

Movement data
⇒ action command

- Walking
- Running
- Biking
- Skiing
- Eating
- Sleeping
- ...

Can you think of three examples, how activity recognition might be used in a real-life-context?

....

....

....

Among various classification techniques two main questions arise:

What action
→ recognition

"What action?" (i.e., the recognition problem) and
"Where in the data?" (i.e., the localization problem).

Where is it
→ localization.

The development of a fully automated human activity recognition system with low error poses many different challenges, such as:

- Background clutter / noise in the data
- Partial occlusion
- Changes in scale
- Viewpoint, lightning, appearance (with a video-based system)
- Data resolution

The way that humans perform an activity depends on their habits, and this makes the problem of identifying the underlying activity quite difficult to determine.

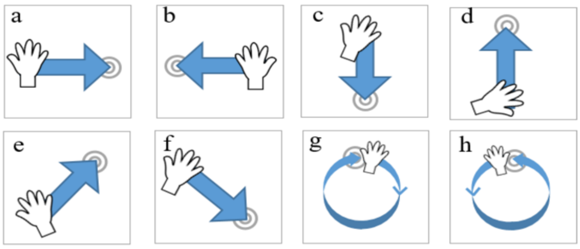
To overcome these problems, a task is required that consists of three components – namely:

Remove b.g.

1. Background or noise subtraction – in which the system identifies the data that is used for activity classification
2. Human tracking, in which the system locates human motion over time
3. Human action detection, in which the system identifies the actions and depending on their complexity, human activities can be categorized in:
    a. Gestures
    b. Atomic actions
    c. Human-to object or human-to human interactions
    d. Group actions
    e. Behaviours
    f. Events

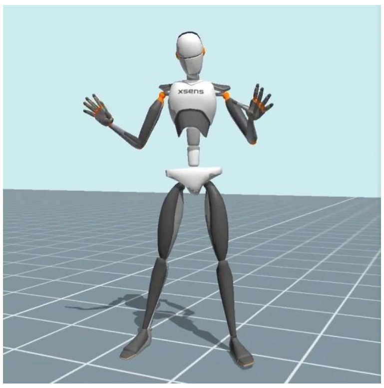
primitive movements

Contactless.



Gestures are considered as primitive movements of the body parts of a person that may correspond to a particular action of this person

Hand gesture recognition-based HCI provides an intrinsic contactless interface, bringing humans one step closer to a natural mode of interaction. These interactive HCI models have potential to be implementable in contactless environments, such as operating rooms and sign language-based communication systems.



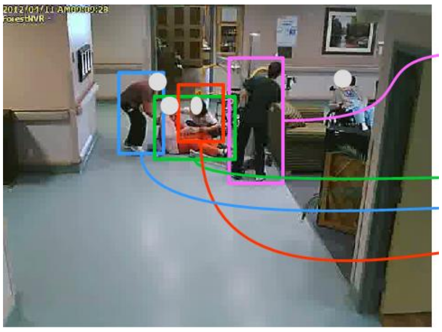
Atomic actions are movements of a person describing a certain motion that may be part of more complex activities. By decomposing the activity into smaller parts, atomic actions help to identify bigger patterns. (E.g., cutting is a part of cooking).

smaller part of a more complex activity.

Source: https://virtualhumans.mpi-inf.mpg.de/behave/

Action type & object-in-use

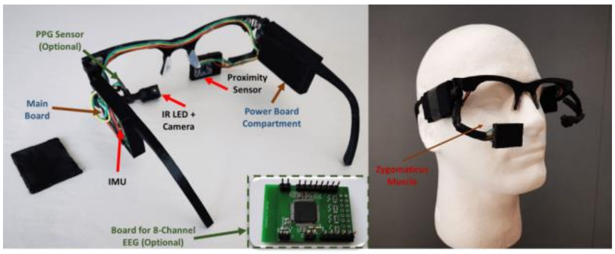
Human-to object or **human-to human interactions** can give deep insights into the currently performed activity and influence the analysis.
There exists strong correlation between the action type and the type of object-in- use. For example, it is most likely to perform cutting with a knife in hand. Therefore, knowing what object is currently being operated gives us very important information on what action is being performed.



Deng, Z., Zhai, M., Chen, L., Liu, Y., Muralidharan, S., Roshtkhari, M.J., & Mori, G. (2015). Deep Structured Models For Group Activity Recognition. *BMVC.*

Group actions are activities performed by a group or persons

Human behaviors
↪ physical actions



Source: http://icsl.ee.columbia.edu/projects/spiders-wearable-emotion-sensing/

Human behaviors refer to physical actions that are associated with the emotions, personality, and psychological state of the individual

emotions,
psychological
state

Events - high level actions

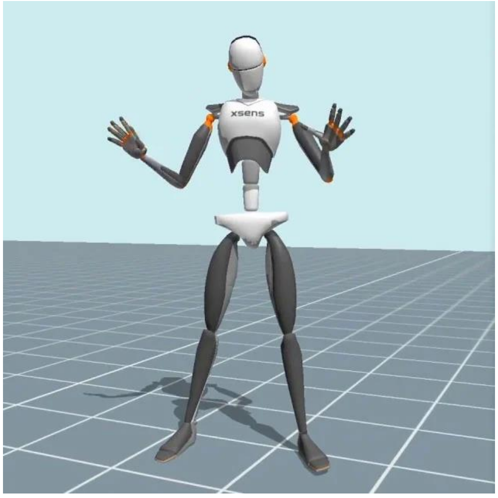
Events are high-level activities that describe social actions between individuals and indicate the intention or the social role of a person

[3] Categories of deep learning in sensor-based human activity recognition

Activity recognition can be done using camera-based data or sensor-based. Due to the proliferation of smart devices and the Internet of Things, sensors can be easily embedded in portable devices nowadays. Smart phones, smart watches or sensors embedded in non-portable objects, such as cars make the use of sensor-based activity recognition part of everyday life and allow the non-intrusively logging of human motion. [3]

Deep Learning for Sensor-based Human Activity Recognition: Overview, Challenges, and Opportunities
Chen, K., Zhang, D., Yao, L., Guo, B., Yu, Z., & Liu, Y. (2021)

Example of activity recognition in research

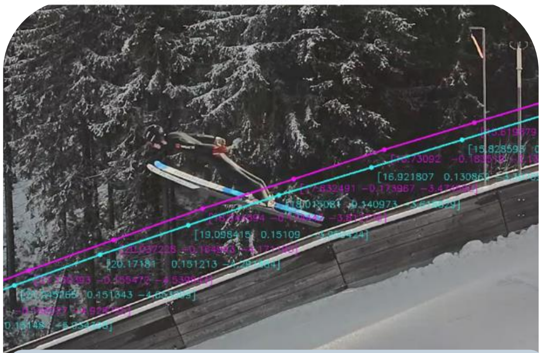


One example of how sensor technology can be used for activity recognition, is the recently established Collaborative Research Centre (CRC) "EmpkinS". The focus of EmpkinS is capturing human motion parameters remotely in a minimally disturbing and non-invasive manner and with very high resolution. The physiological and behavioural states underlying the motion pattern are then reconstructed algorithmically from this data, using biomechanical, neuromotor, and psychomotor body function models. The sensors, body function models, and the inversion of mechanisms of action establish a link between the internal biomedical body layers and the outer biomedical technology layers. Research into this link is highly innovative and extraordinarily complex, and many of its facets have not been investigated so far.

[4] https://www.xsens.com/products/xsens-gloves-by-manus

https://www.empkins.de/about/crcempkins/

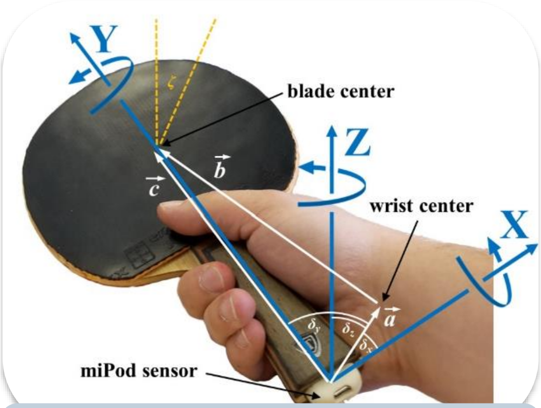
Example of activity recognition applied to out of laboratory contexts



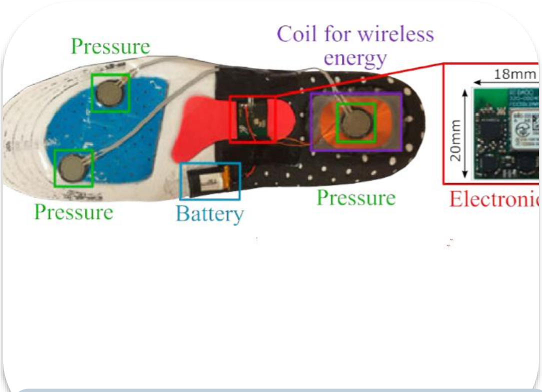
Real-Time Ski Jumping Tracking System, Link et al., 2021 [4]

Real-time tracking for the quantification of ski jumping is one field of application of activity recognition. The abovementioned research used a tracking system that consists of wearable trackers, which are attached to the ski bindings of athletes and fixed antennas next to the jumping hill. It can be used to measure the 3D positions and the ski angles during a jump.

More examples of how activity recognition might be used:



Ball speed and spin estimation in table tennis, Blank et al., 2017 [5]



Sensor Insoles for Gait Analysis, Roth et al., 2018 [6]

References

[1] https://unsplash.com/photos/PHIgYUGQPvU
[2] https://indatalabs.com/blog/human-activity-recognition
[3] Chen, K., Zhang, D., Yao, L., Guo, B., Yu, Z., & Liu, Y. (2021). Deep learning for sensor-based human activity recognition: Overview, challenges, and opportunities. ACM Computing Surveys (CSUR), 54(4), 1-40.
[4] https://www.xsens.com/products/xsens-gloves-by-manus
[5] Link, J., Guillaume, S., & Eskofier, B. M. (2021). Experimental Validation of Real-Time Ski Jumping Tracking System Based on Wearable Sensors. Sensors, 21(23), 7780.
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[7] Roth, N., Martindale, C. F., Eskofier, B. M., Gaßner, H., Kohl, Z., & Klucken, J. (2018). Synchronized sensor insoles for clinical gait analysis in home-monitoring applications. Current Directions in Biomedical Engineering, 4(1), 433-437.

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