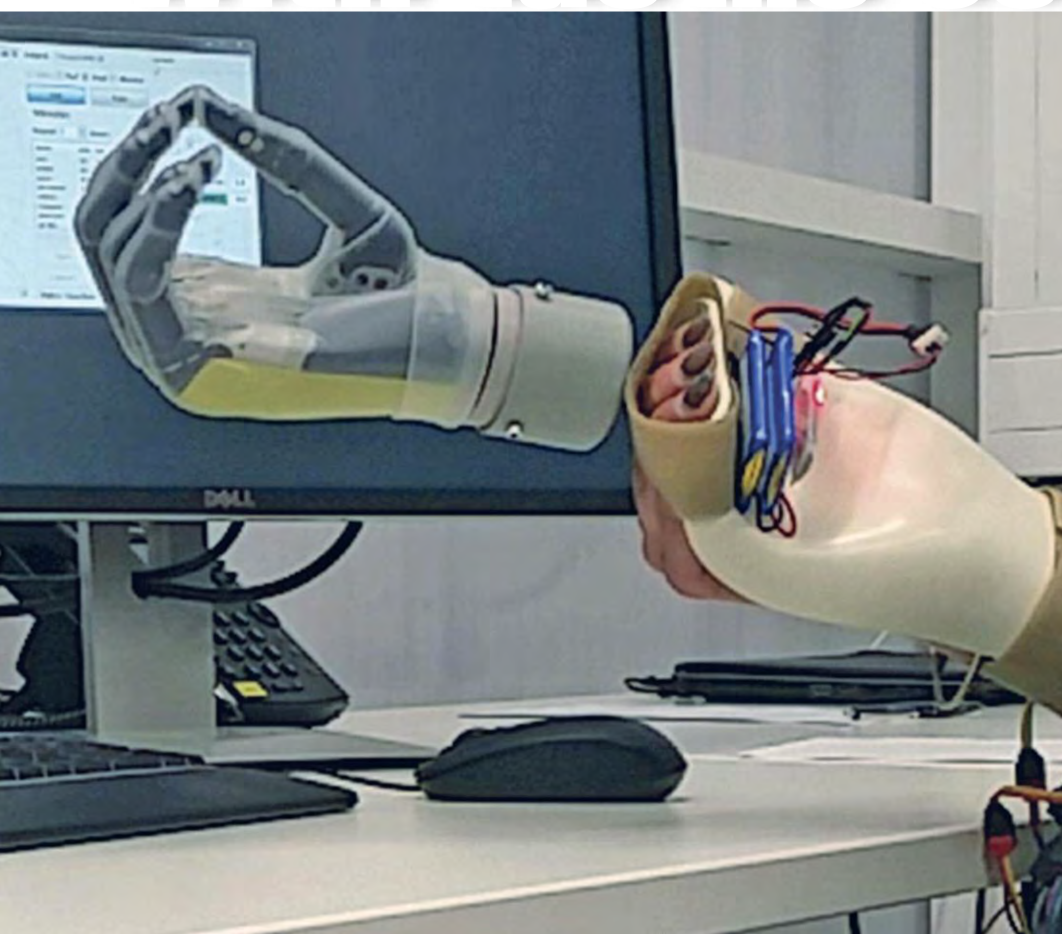
«The machine learning approach we develop takes into account the underlying structure and geometry of both sEMG and tactile array data.»

Sylvain Calinon, heading the Robot Learning and Interaction group at Idiap

Despite recent advances in prostheses, intuitive and robust control of poly-articulated prosthetic hands remains an unsolved problem. The TACT-HAND project aims at providing hand amputees with improved dexterous capabilities by exploiting tactile sensing and innovative machine learning methods.

Improving the control of prosthetic hands with tactile sensing



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The TACT-HAND project proposes to employ a new generation of tactile sensors coupled with efficient, innovative intent detection methods by exploiting recent advances in machine learning. The final goal is to provide amputees with a stable, reliable and user-friendly control of their prosthetic hands. The TACT-HAND project bases its development on the I-LIMB Ultra prosthetic hand by Touch Bionics. It involves researchers from Germany (German Aerospace Center and Bielefeld University) and Switzerland, with support from the Swiss National Science Foundation (SNSF) and the German Research Foundation (DFG). The machine learning aspects of the project are conducted at Idiap, a research institute specialized in artificial intelligence located at Martigny in Valais.

Most of the previous technologies were based on surface electromyography (sEMG) as the main modality to infer hand movement intent in a non-invasive way. Despite the light weight, low cost and ease of embedding these sensors, the drawbacks of sEMG make the exact activity intention not yet possible. Due to the high number of muscles packed side by side in the lower arm, the signal delivered by the electrodes takes the form of a noisy mixture of muscles activity patterns. sEMG can also often be unstable due to sweat and movement of the electrodes.
The breakthrough of TACT-HAND is to exploit tactile sensing as an additional information about the movement intent. When activated, the shapes of the muscles change, inducing a pressure on the surface of the forearm. A shape conformable tactile bracelet is developed in the project to capture muscles bulges. Depending on the circumference of the forearm, between seven and ten tactile sensor module of 32 electrodes (in a 4 by 8 arrangement) are assembled together. The tactile sensors are based on elastomer foam, so that they exploit the change in the interface resistivity between two electrodes of a cell according to the applied load. The bracelet allows the acquisition of tactile data at low cost, low power consumption and simple usability.

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Noémie Jaquier,
PhD student working on TACT-HAND

Tactile and sEMG data are then combined and processed by machine learning techniques developed at the Idiap Research Institute. The idea of machine learning is to allow a computer to learn without explicitly being programmed. In the case of controlling prosthetic hands, examples of tactile and sEMG input coupled with the associated hand or wrist movement are provided to the system. The developed model then learns the relationship between the input signals and the output movement, which is then used to make predictions when new input data are provided. The challenge of developing such a model is that the associated algorithm needs to adapt the control of the prosthesis when new situations are encountered.
The novelty of TACT-HAND is that it considers the whole range of movement (including hand and wrist), as opposed to fixed poses. It means that the developed learning algorithm aims at recognizing how much a patient would like to open his/her hand instead of providing only closed and opened hand poses (regression vs. classification). In order to cope with such challenge, the approach developed at Idiap consists of taking into account the underlying structure and geometry of the data in the machine learning process.

Preliminary evaluations conducted on able-bodied participant, using only tactile array data, confirmed the feasibility and promises of the approach, and showed that the proposed method can successfully recognize movement intent. Future work includes the evaluation of the designed methods on amputees.

www.idiap.ch/project/tact-hand

1. Experimental setup to test the i-LIMB prosthesis with able-bodied participants.

2. sEMG and tactile sensors wrapped around the forearm as a bracelet.

3. Experimental setup: the participant, wearing the developed tactile array bracelet, is asked to imitate the white hand pose observed on the screen, while controlling the skin-colored hand.

3.