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Appendix 1: Content Summaries of Selected Best Papers for the 2022 IMIA Yearbook, Section Sensors, Signals, and Imaging Informatics

Jeong H, Kwak SS, Sohn S, Lee JY, Lee YJ, O'Brien MK, Park Y, Avila R, Kim JT, Yoo JY, Irie M, Jang H, Ouyang W, Shawen N, Kang YJ, Kim SS, Tzavelis A, Lee K, Andersen RA, Huang Y, Jayaraman A, Davis MM, Shanley T, Wakschlag LS, Krogh-Jespersen S, Xu S, Ryan SW, Lieber RL, Rogers JA

Miniaturized wireless, skin-integrated sensor networks for quantifying full-body movement behaviors and vital signs in infants

Proc Natl Acad Sci U S A 2021 Oct 26;118(43):e2104925118

The detection of atypical movement behaviors in infants is critical for timely therapeutic interventions based on early childhood neuroplasticity. In this work, the authors impressively present a simple, cost-effective alternative in the form of a customized technology to quantitatively record whole-body kinematics of infants under free-living conditions while recording important vital signs. Since conventional assessments rely on subjective expert evaluations or specialized medical facilities, the technology used is based on wireless networks of miniaturized, skin-integrated sensors placed at strategic locations across the body, operating in a wide-bandwidth and time-synchronized fashion. Recorded data of individual movement behavior serve as the basis for reconstructing three-dimensional motion in the form of avatars, without the need for video recording and the associated privacy concerns. Clinical application in infants at low and increased risk for atypical neuromotor development demonstrates the applicability of this system with quantitative assessment of patterns of gross motor skills, along with cardiopulmonary information such as body temperature, heart and respiratory rate from long-term and follow-up measurements over a 3-month period after birth. The work stands out for its excellent applicability, as the outputs from these sensors can be linked to established educational resources on motor development via mobile applications to support early detection of abnormalities in home and clinical settings. The technology presented thus enables rapid, routine evaluations of infants at any age and has potential for use in nearly any setting across developed and developing countries.

Ganapathy N, Baumgärtel D, Deserno TM

Automatic detection of atrial fibrillation in ECG using co-occurrence patterns of dynamic symbol assignment and machine learning

Sensors (Basel) 2021 May 19;21(10):3542

Early detection of atrial fibrillation from electrocardiography (ECG) plays a vital role in the timely prevention and diagnosis of cardiovascular diseases. Symbolic classifiers aim at capturing the concepts behind the measured data. As novelty, this paper relates symbols to the definition range to the signal, but not to the value range, as previous approaches exclusively did. In particular, the authors transform interbeat intervals into an adaptive symbolic representation and compute co-occurrence matrices on the symbols. They vary symbol-length, word-size, and applied to five machine learning algorithms for classification. The approach is tested on public available data (AF Prediction Challenge Database (AFPDB) and AF Termination Challenge Database (AFTDB)) as well as private data from capacitive and textile ECG electrodes, the latter providing noisy recordings. The approach outperforms the state of the art in terms of accuracy and is efficient for real-time and mobile applications, and robust on noisy data.

He Y, Carass A, Zuo L, Dewey BE, Prince JL

Autoencoder based self-supervised test-time adaptation for medical image analysis

Med Image Anal 2021 Aug;72:102136

The use of deep neural networks for medical image analysis tasks such as segmentation and synthesis has become very important in recent years. A major challenge remains the problem of performance drop, even when a network is trained on a large dataset. In this work, the authors propose a model that adapts during inference based on a single subject to overcome the lack of availability of training data and the cost of training a new model. The model consists of three neural networks: (i) a task model which can be any state-of-the-art model that performs image analysis, e.g. segmentation, (ii) a set of multi-level fully convolutional autoencoders to encode the image level, feature levels, and output prediction level distributions of the source domain, and (iii) a set of adaptors that test data to the source domain in both, the pixel-level and feature-level to improve the final prediction. The task model and autoencoders are trained with a labeled source dataset. This is computationally expensive, but the model only needs to be trained once. In the deployment stage, the adaptors are trained to transform the test image and its features to minimize the domain shift as measured by the autoencoders' reconstruction loss, which is computationally efficient. The method achieves significant performance improvement and was validated on retinal optical cohenrece tomography image segmentation and MRI T1-weighted to T2-weighted image synthesis. The work is noteworthy for its high potential for developing a clinically robust and easily deployable deep network.