UNIVERSITÉ DE NANTES

CENTRE HOSPITALIER UNIVERSITAIRE DE NANTES

LS2N

Phd Subject

Deep Learning for morphokinetic information extraction on time lapse microscopy images of human embryo

Localization : LS2N – IPI team, Polytech Nantes, FR

Supervisors:

Harold Mouchère (harold.mouchere@univ-nantes.fr),

Thomas Fréour (thomas.freour@chu-nantes.fr)

Key Words : deep-learning, video analysis, biological image processing

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Context

The recent implementation of time-lapse technology in In Vitro Fertilization (IVF) led to an improvement in embryo quality assessment methods and improved culture conditions. One of the limitations of the clinical studies performed with time-lapse microscopy is related to the inter-laboratory variation in annotating embryo morphokinetic parameters, a time-consuming activity. Setting up a software tool for automated annotation of embryo development would allow faster and more reproducible analysis of embryo development, finally allowing homogeneous, large scale and high throughput analysis of several existing databases.

These tasks correspond to several image analysis challenges such as object segmentation, counting and measurement regression. Classical image analysis tools require several ad hoc intermediate steps to extract dedicated features that are then merged to compute the embryos score. To avoid this empirical and hard to optimize process, state-of-the-art deep learning tools will be used for these tasks.

The development of this automated analysis pipeline will take advantage of our local database of more than 1000 annotated videos of embryo development up to the blastocyst stage to train and evaluate the deep-networks.

Scientific objectives

Convolutional deep networks have proven to be successful in extracting high-level knowledge from raw image data. As microscopy time-lapses provide sequential information and the embryo development is a sequence of stages, recurrent topologies designed for sequence to sequence labeling have also to be investigated. Recent deep-learning attention based systems allow to extract a form of explanation of the outputted results by focusing on relevant parts of the input signals, which is a interesting feature for medical applications. Existing empirical image processing solutions designed specifically for these tasks can be used to improve the training or analysis of proposed neural network based architectures. Finally, biological information will be merged with these visual information to predict a global evaluation of the quality of embryo.

References

Khosravi, Pegah, et al. "Deep learning enables robust assessment and selection of human blastocysts after in vitro fertilization." *npj Digital Medicine* 2.1 (2019): 21.

Milewski, Robert, et al. "How much information about embryo implantation potential is included in morphokinetic data? A prediction model based on artificial neural networks and principal component analysis." *Advances in medical sciences* 62.1 (2017): 202-206.

Singh, Amarjot, et al. "Automatic segmentation of trophectoderm in microscopic images of human blastocysts." *IEEE Transactions on Biomedical Engineering* 62.1 (2014): 382-393.

Graves, Alex, Abdel-rahman Mohamed, and Geoffrey Hinton. "Speech recognition with deep recurrent neural networks." *2013 IEEE international conference on acoustics, speech and signal processing*. IEEE, 2013.

Xu, Kelvin, et al. "Show, attend and tell: Neural image caption generation with visual attention." *International conference on machine learning*. 2015.

Yun, Sangdoo, et al. "Action-driven visual object tracking with deep reinforcement learning." *IEEE transactions on neural networks and learning systems* 29.6 (2018): 2239-2252.

Valipour, Sepehr, et al. "Recurrent fully convolutional networks for video segmentation." *2017 IEEE Winter Conference on Applications of Computer Vision (WACV)*. IEEE, 2017.

Required Skills

Master computer science or data science

- Machine learning, Neural network, deep-learning
- Image processing
- Statistics

Programming skills

- Python / C++
- deep-learning lib (pytorch, tensorflow …)