Online extraction of functional data from video recordings of gut movements using AI features

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Abstract. The gut is an often underestimated organ which contributes significantly to our health condition 1 . It is also one of the main entry gates for pathogens, toxins or drugs, thus influencing the whole body. The gut harbors an intrinsic and autonomeously working nervous system, the socalled enteric nervous system (ENS) that regulates blood flow, resorption, mucosal barrier function and gastrointestinal motility. The gastrointestinal motility is an appropriate readout to evaluate the health status of the whole organ, since all kind of compromising or challenging agents, either orally or systemically administered will affect the ENS 2,3,4 . Moreover the gut can be compromised in various diseases. During the last years, the role of the gut in neurodegenerative processes and diseases came more and more into focus and it could i.e. be demonstrated that gut motility changes also in models of Alzheimer and Parkinsons disease (PD) 5,6 . In PD patients, gastrointestinal problems often appear long before the disease is diagnosed. In a recent study it could nicely be demonstrated that in very young (2 month) mice that overexpress the alpha synuclein pathogenic peptide, the alteration of colonic motility was related to molecular alterations of the ENS 7 . While the use of muscle strips with the included ENS to investigate isometric contractions is a rather artificial approach, using intact gut segments with intact mucous layers and even if necessary, mesenterial perfusion, can deliver much more in vivo equivalent data to analyse gut activity under the influence of external or systemic factors.

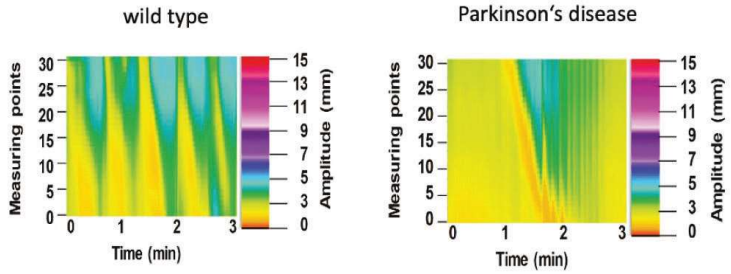

Figure 1 Heat maps that represent the movement of the colon in a PD model (right) compred to the wild type mouse colon. While the WT shows a continuous series of propagating contractions, the PD gut is rather slow.

Gut segments from the colon of adult mice were fixed in a tubing system and placed in an organ bath under continuous luminal perfusion. The perfusion was performed using an efflux resistance of 3cm H 2 O to induce gut movements. The organ bath chamber was equipped with a frontal and bottom glass plate, so that a continuous video recording from

front and bottom could be realized. The gut was perfused and superfused with a 37°C warm Tyrode buffer solution at an pH of 7,4. The buffer was oxygenized prior to perfusion to obtain a sufficient oxygen saturation. The gut was allowed to equilibrate for 10 min after fixaton in the organ bath under physiological conditions. Then the experiment was started. Two cameras, positioned either in front or at the bottom window of the organ bath chamber, were started at the same time and the spontaneous activity ot the gut recorde for 10 min. Then the gut was challenged with individual drug compounds to stimulate its activity for another 10 min. At the end of the experiment, a maximal stimulation was achieved using Acetylecholine. To analyze the movement of the gut, initially 33 virtual dots positions are selected on the boundary of the gut manually. Then, in each frame of the video, vertical movement of the dots is tracked using distance transforms while considering the fixed horizontal position. Then, the distance of every dot is measured to the corresponding dot in the previous frame. In this way, gut movement is tracked in the complete video. The heat map of the movement is presented in the Figure below:

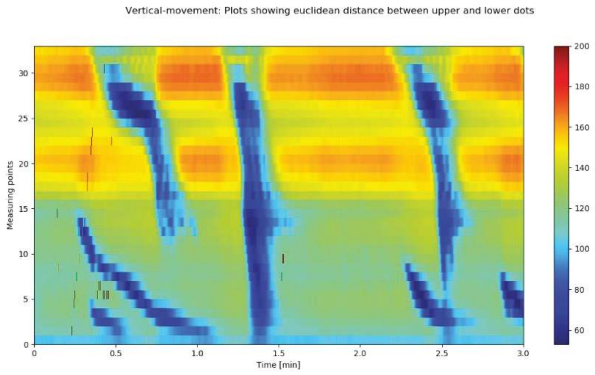

Figure 2 Heat map presents the vertical movement of guts in a video.

The approach demonstrates the use of AI algorithms to extract valuable and quantifiable data from gut movements online in real time. This allows to investigate the impact of either drugs, toxins, nutritional components or even diseases upon gastrointestinal motility. The method delivers timely and spatial resolution of gut movements, so that a detailed analysis of functional distinct entities of the gut (i.e. proximal and distal colon) can be evaluated and compared.

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