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New tools for functional and morphological data analysis and quality management in biological research

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Data analysis plays a crucial role in biological research, enabling scientists to extract meaningful insights from complex datasets. Understanding the dynamic behavior and structural characteristics of biological systems is essential for uncovering underlying mechanisms, identifying biomarkers, and developing new treatments.
Throughout the collaborative doctoral program titled:"Tissue analytics for stem cell-based diagnostics", a significant volume of data was generated across multiple projects. Manual analysis of this data is resource intensive and error prone.
The aim of this thesis is to automate the data analysis by harnessing computational algorithms to efficiently extract insights. The focus is on functional and morphological data analysis. Functional and morphological data analysis techniques are vital for understanding biological processes at different scales, from the molecular level to complex organisms. Functional data analysis can provide valuable insights into the underlying mechanisms governing physiological processes, as the filtration rate of glomeruli in the kidneys. Morphological data analysis, on the other hand, focuses on the study of shape, structure, and form within biological systems. It involves techniques for quantifying and characterizing various morphological features, ranging from cellular and tissue structures to whole organ shapes.
The analysis of functional and morphological data poses various challenges. These include dealing with high dimensionality, handling noisy or missing data, accounting for dependencies within the data, ensuring data quality and reliability, and developing appropriate statistical models and computational algorithms. Overcoming these challenges requires the development of innovative methodologies, statistical frameworks, and computational tools tailored to the specific characteristics of the data and the biological questions being addressed.
Specifically, this thesis addresses data analysis challenges associated with functional data from transcutaneous measurements of glomerular filtration rate and morphological data from colony forming units. Transcutaneous measurement of glomerular filtration rate allows for the animal to stay conscious during the non-intrusive procedure and avoids the time consuming serial blood and urine sample collection previously required. The experimenter is assisted by calculating the elimination kinetics curve after the data is collected. Data analysis methods for counting and characterization of colony forming units (CFUs) are developed in order to replace the manual counting with automatic petri dish extraction and detection of each individual CFU as well as the possibility for correction, plotting and managing of the results.
The aim is to advance the understanding of biological systems by automating the evaluation of large amounts of data to a greater extent, to make evaluation possible in the first place or at least to make it more reliable compared to manual evaluation and therefore extracting meaningful insights from complex datasets.