1. Information about the project

Our Urology Department's MSc/BSc offers a unique platform for students, to merge medicine, biology, and technology to enhance bladder cancer treatment. This project is structured into four ten-week stages, each fostering unique skills and addressing different aspects of the clinical problem.

In the first ten weeks, students will focus on developing machine learning algorithms to predict patient responses to BCG treatment. These algorithms will leverage cell nuclei features derived from histopathological images. This stage will provide an immersive learning experience in image analysis, feature extraction, and machine learning model training.

During the second stage, the project will expand the algorithms to predict molecular subtypes of bladder cancer. By analyzing cell nuclei features and extracting features from histopathological images for deep learning models, we aim to create a holistic and reliable prediction tool. This phase will build upon students' data integration, model validation, and biomedical informatics skills.

The third period will shift focus to the construction of a fusion model. This model will incorporate clinical data, extracted image features, and molecular subtyping data, offering a comprehensive prediction of patients' responses to treatment. Creating this fusion model will offer students the opportunity to learn about and experiment with advanced data integration and fusion techniques.

The final ten-week stage involves refining and validating the developed fusion model. This includes rigorous performance testing and refinement to ensure the models' robustness, generalizability, and reliability for clinical application. During this phase, students will apply attention mechanisms to the deep learning model, enabling them to trace back the decision-making process of the algorithms. By focusing on the specific areas that the model uses to base its decisions, students can gain insight into how the model interprets data and makes predictions. This process will provide valuable insight into the interpretability of artificial intelligence models, a crucial aspect of their clinical applicability.

By the end of the project, students will have gained firsthand experience in the application of AI in medicine, with a specific focus on bladder cancer diagnosis and treatment. Supported by our multidisciplinary team and our international partners, students will obtain practical skills and make valuable contributions to the field of life science and technical medicine. The ultimate aim is to equip students with the skills and knowledge to innovate and excel in this rapidly evolving field.

2. Information about the department and research group

Together with you, we will ace the challenges of technical medicine and revolutionize the field of urology. Our Urology Department at Erasmus MC is enthusiastic of using artificial intelligence techniques to improve diagnosis and prognosis prediction for bladder cancer patients.

Our multidisciplinary research group combines expertise from clinicians, biologists, and technical specialists, enabling us to push scientific boundaries and implement innovations in clinical practice for the benefit of patients and healthcare providers. We are leveraging the

results of the EU-funded Clarify Project (www.clarify-project.eu) and collaborating with renowned institutions like John Hopkins Medicine, Radboud MC, TU Delft, Bridgester Consortium, and the University of Stavanger. You will have direct contact with these partners.

Our research efforts have primarily focused on applying image analysis and machine-learning techniques to histopathological images. We developed algorithms that can improve bladder cancer prognosis prediction. Now, our aim is to further refine and expand these algorithms by integrating different data modalities, thereby advancing the field of urology.

With your participation and expertise, we will continue to push the technical medicine boundaries, unraveling new possibilities for the early detection, accurate diagnosis, and personalized treatment of bladder cancer patients. Together, we will make groundbreaking strides toward improving patients' clinical outcome.

3. Research question and the desired result

Main question: How can machine learning methods improve diagnosis and prognosis of bladder cancer patients?

Subquestion1: How can machine learning algorithms, trained on histopathological images, predict the response of bladder cancer patients to BCG treatment?

Subquestion2: How can machine learning algorithms, trained on histopathological images and cell nuclei features, predict molecular subtypes in bladder cancer patients?

Subquestion3: How can a fusion model, incorporating clinical data, image features, and molecular subtyping data, provide a comprehensive prediction of patients' responses to treatment?

Subquestion: How can the application of attention mechanisms to the fusion model enhance our understanding of the algorithm's decision-making process and improve its interpretability?

4. Clinical and technical experiences within the internship

- Machine learning and image analysis
- Using artificial intelligence for medical prognosis (analyzing clinicopathological data)
- Using artificial intelligence in computer vision for histopathological image analysis
- Making fusion models to combine clinical, image, and transcriptomic data
- Visiting OR for Radical Cystectomy
- Visiting OR for Transurethral Resection of Bladder Tumor (TURBT)
- Visit Outpatient Clinic
- Visit Cystoscopy

A structured schedule will be drawn up for each student to ensure they are able to participate in all these activities. The schedule will be flexible to accommodate the student's academic re

quirements and to optimize their learning experience during the internship.

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