**INFO-B 691: Project/Thesis Pre-Assessment Form**

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**Project**

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**Semester to be enrolled in: Spring 2025**

**Personalized Prognosis for Chronic Wound Healing: Predicting Healing Time Using a Multivariate Approach**

**1. What are your personal and professional goals for this project/thesis?**

Personal goals: My personal goal is to work on an independent capstone project and contribute to the development of personalized healthcare decision support tools using machine learning approaches.

Professional goals: My professional goal is to be able to apply an advanced machine learning techniques to derive meaningful insights from multivariate datasets, combining demographic, clinical data and treatment histories. This would equip me with experience in creating a system that can be practically used in clinical settings.

**2. Give a detailed description of your project/thesis.**

* **Introduction:**

This project focuses on creating a personalized prognosis system for predicting the healing time of chronic wounds based on individual patient factors. The model will incorporate multivariate data such as patient demographics (age, gender, comorbidities), Wound characteristics (size, depth, stage, infection, necrosis, wound size, granulation, fibrin), and Treatment data (medication, compliance). Using this data, a machine learning model will be developed to predict healing time in days and provide a confidence interval (uncertainty estimates) around that prediction. This effort aligns with current advancements in personalized medicine, emphasizing the use of machine learning and predictive analytics to improve patient-specific care (Veličković et al., 2023).

* **Knowledge Gap in the area:**
* **Lack of Personalization:**  
  Current clinical guidelines often apply population-level recommendations, which fail to address individual variability in wound healing outcomes (Bender et al., 2021). The factors that affect wound healing are very subjective, which calls for a need to develop personalized models for the patients.
* **Data Complexity and Heterogeneity:**  
  Chronic wounds are influenced by multiple factors, including patient demographics, comorbidities, wound characteristics, and treatment regimens. Managing this heterogeneity requires advanced data-driven approaches.
* **Uncertainty in Predictions:**  
  Existing models rarely account for uncertainty, which is critical in clinical decision-making. For instance, clinicians often lack tools to gauge confidence intervals for predicted recovery timelines (Krauth et al., 2016). This project aims to employ multiple models to understand the accuracy of prediction.
* **Limited Integration with Standardized Clinical Documents:**

Many existing wound care tools lack the capability to directly process structured clinical documents such as Continuity of Care Documents (CCDs) and Clinical Document Architecture (CDA) files, which are widely used for storing and sharing healthcare information (Pereugu et al., 2023). This project addresses this gap by designing a system that can import and analyze CCD/CDA files, extracting relevant patient and wound-related data automatically.

* **Aim**

This project aims to develop a machine learning-based system to predict healing time in days based on various patient factors that are commonly recorded for patients undergoing treatment for chronic wounds. When integrated in Clinical decision-making tools, the project will equip clinicians with actionable insights into patient recovery timelines, improving decision-making. It provides patients with transparent, understandable recovery forecasts, fostering trust and compliance with treatment plans.

* **Objective:**

The objective of this project is to develop a system that utilizes machine learning to integrate both static (e.g., demographics, comorbidities) and temporal data (e.g., wound progression) related to wound healing and gives accurate prediction of healing times based on this data.

To develop this system, several machine learning models will be implemented and compared to assess their performance on the dataset. A Transformer-based model, with a deep learning architecture, will be utilized for its ability to process both static and temporal data effectively. By employing attention mechanisms, it can identify and prioritize relevant features, enhancing prediction accuracy. Monte Carlo Dropout will be applied to estimate uncertainty in the predictions. A sequential model, such as Long Short-Term Memory (LSTM), will be incorporated to capture temporal patterns in wound healing data. An Autoregressive Integrated Moving Average (ARIMA) model, which is well-suited for time-series data, will model dependencies based on past observations, making it an appropriate choice for the temporal nature of wound care data. Lastly, a Random Forest model along with the ARIMA model will serve as baseline for comparison.

**3. What is the purpose of your project/thesis?**

The idea of this project is based on the growing importance of precision medicine, Weigelt et al. (2020) discuss how non-healing chronic wound have been a growing global health crisis, with mortality rates and management costs surpassing many cancers. They have emphasized that the need of the hour is to develop point-of care-diagnostic tools which are predictive, prescriptive, and personalized. Individualized risk management tools using machine learning have previously been utilized and have been found to be useful in chronic wound management (Velickovic et al., 2023). Peterson et al. (2017) have previously encouraged the idea of moving away from one-size-fits-all population models to personalized predictive models that adapt to each patient's unique clinical data over time to provide tailored predictions. They achieved this using a personalized Gaussian Processes (pGPs), which incorporate patient-specific data (e.g., cognitive test scores, imaging biomarkers, and demographics) to refine the population-level model for individual use for Alzheimer’s disease progression. The gap here is that these GPs can only work on data which is small and cannot predict long term variations or complex temporal relationships which are important with respect to the multivariate nature of factors affecting the progression of wound healing (Krauth et al., 2017). They also heavily rely on the quality and completeness of the historical data which further limits their use (Peterson et al., 2017). To overcome these shortcomings, a transformer model-based approach is adopted for this project as these models are good with large dataset and handling complex relationships and long-term variations. The GP models are good with calculating the uncertainty of prediction and to obtain this in a transformer model technique like Monte-Carlo dropout will be used, which will allow the model to generate multiple predictions for each input, capturing the variability in healing outcomes and providing confidence intervals. This will be an indication of how confident the mode is about these predictions. The variables in the study are taken from a previous study by Bender et al. (2021) where these variables proved to be most informative.

**4. Who is the target audience of your project/thesis? (Be specific)**

Primarily Clinicians, nurses, and wound care specialists who manage chronic wounds and make decisions about treatment plans and patient care**.** Secondarily, patients who are undergoing treatment and hospital administration in charge of maintaining resources and inventory necessary to provide timely care to these patients.

**5. State your expected outcomes or deliverables of this project/thesis.**

* A trained predictive model capable of estimating the healing time of chronic wounds based on patient-specific data.
* A comprehensive evaluation report detailing the model’s accuracy.
* Visualizations: Line charts and other visualizations comparing performance metrics across the different models, Visualization of the healing trajectory which shows the predicted trajectories of different models and a Feature importance plot showing important features determining healing time.
* An application where we can upload a CCD/C-CDA, which will then allow the user to select the appropriate variables from the CCD/C-CDA to map with the trained models features, and then allow to make the predictions. This app could be deployed as Streamlit or some other notebook/dashboard interface.

**6. State expected timeline of your project/thesis. Be sure to include benchmark times that can be checked by faculty advisor.**

* Week 1-2: Literature review and data collection.
* Week 3-4: Data preprocessing and initial analysis, UI development
* Week 5-8: Model Training
* Week 8-10: Model testing and evaluation, fine-tuning for improvement.
* **Week 11-12: UI implementation and app development**
* Week 13: Reporting writing.

**7. Projected resources and or sources of information you will need to complete the project successfully.**

* Comprehensive dataset of anonymized wound healing and treatment outcomes.
* Software, programming and computational resources for model training and testing,

**8. Strategies of assessment and or usability studies. Detail how you plan on determining the success of this project/thesis.**

Evaluate and compare these different models for accuracy using mean absolute error (MAE) and root mean squared error (RMSE), mean squared error (MSE), mean absolute scaled error (MASE) and R squared for healing time prediction.

Using a separate test set to validate the model and check its generalizability with unseen data, then compare the model’s predictions to actual outcomes to check for accuracy.

**9. What new information do you think you will gain by doing this project/thesis?**

Practical experience in applying transformer-based models for real-world healthcare problems and learning how to deal with complex, multimodal patient data.

References:

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