Deep Learning in Intraoperative Forecasting

Team: Chuheng Yu, Weiming Wang, Xin Su, Tyler Christoforo

Background

Intraoperative Hypotension
-   **Description:** A critical medical condition that occurs during surgery when a patient's blood pressure drops to levels below the normal range
-   **Risk:** Lead to organ hypoperfusion, increased blood lost, cardiac events, etc
-   **Threshold:** No clear definition; threshold vary depending on patient's age, underlying medical conditions, type of surgeries, etc

Forecasting Importance
-   **Enhance Patients' Intraoperative Safety:** Allows to take proactive measures, preventing complications and improving patient safety during surgery
-   **Optimize Anesthesia Management:** Helps maintain stable blood pressure, optimizing anesthesia management for better surgical outcomes
-   **Reduces Postoperative Risks:** Risk of postoperative complications, such as organ damage, stroke, or extended hospital stays, is reduced

Framework
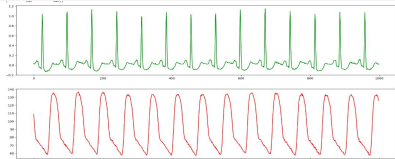
Data Source	Data preprocessing	Model preparation	Evaluation

- VitalDB

- Data extraction
- Feature selection
- Data cleaning

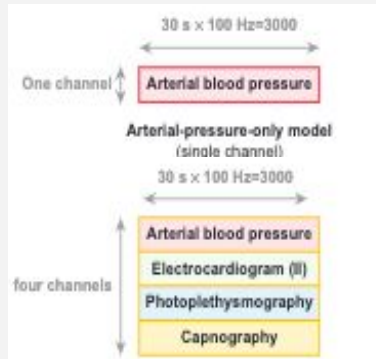- Data conversion
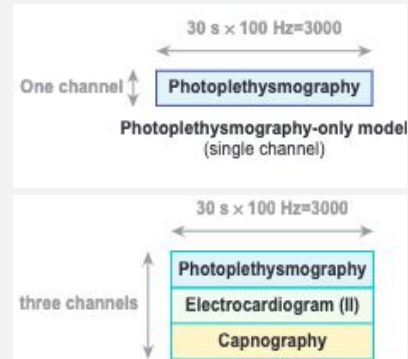- Test train split
- Forecast regression model (LSTM)

- MAE
- Future improvements

Related Research

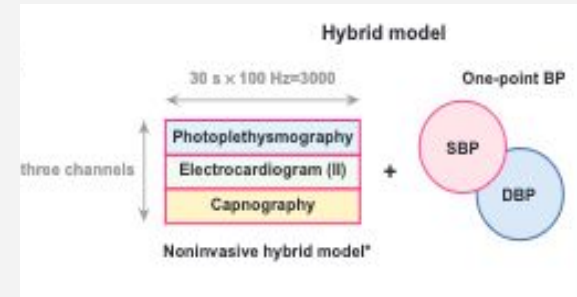| Invasive	Noninvasive	Hybrid

S. Lee et al. *British Journal of Anaesthesia*(2021)

Features

Feature	Description	Type/Hz	Unit	Significance
SNUADC/ART	Arterial pressure wave; represents the pressure throughout the cardiac cycle	W/500	mmHg	MAP decrease can lead to inadequate perfusion of vital organs, increasing the risk of hypotension
SNUADC/ECG_II	Electrocardiogram; records electrical activity of the heart; provides information about heart's rhythm and rate	W/500	mV	Abnormalities in ECG can be early indicators of cardiovascular issues
SNUADC/PLETH	Plethysmography wave; a non-invasive method for monitoring changes in blood volume in peripheral tissues	W/500	unitless	Decrease in the amplitude or quality of the PPG signal can suggest reduced peripheral perfusion
Primus/CO2	Capnography wave; measures the concentration of CO_2 in exhaled breath	W/62.5	mmHg	Sudden decrease in EtCO2 levels may indicate reduced cardiac output and hypotension
Solar8000/BT	Body temperature	N	℃	Elevated body temperature may signal underlying infections, sepsis, or increased metabolic demands

Features

- Other thoughts

  - Invasive vs Noninvasive

  - One-input vs Multichannel

  - Regression vs Classification

Current Progress

- **Focuses:** Intraoperative Hypotension
- **Preprocess: VitalDB API keys**
  - Access all of the .vital files: find_cases, load_case
  - Data cleaning: drop_na
  - 3312 valid surgery cases
- **Model:**
  - 50% training, 25% validation, 25% testing
  - Neural Network model
    - 16 Neurons with "relu" as activation function
    - Optimizar: rmsprop
    - Loss function: MSE
    - Evaluation metrics: MAE
    - Epoch: 10
- **Result:**
  - Test MAE: 23.16

```python
inputs = keras.Input(shape=(pred_lag, df.drop(columns=['event_id']).shape[1]))
x = layers.Flatten()(inputs)
x = layers.Dense(16, activation="relu")(x)
outputs = layers.Dense(1)(x)
model = keras.Model(inputs, outputs)

model.compile(optimizer="rmsprop", loss="mse", metrics=["mae"])
```

Future Improvements

- Preprocess
  - Data Imputation
  - Increase proportion of training dataset
  - Adding prediction for 10 minutes and 15 minutes
- Modeling
  - Increase layers
  - Including more features
  - Use LSTM and other pre-trained models
  - Modify it into a continuous regression prediction
- Vision
  - Invasive or non-invasive
  - Other Intraoperative complications

End Product Vision

- **Real-time Prediction Model**
  - Help reduce postoperative organ dysfunction
  - Proactive intervention
  - Enhance patient monitoring, and offer additional layer of safety

- **Value Proposition**
  - Surgical Support: Serve as a reliable assistant to anesthesiologist during surgery
  - Data-driven Decision Making: reducing reliance on subjective judgment and enhance the accuracy of clinical decisions
  - Efficient Resource Allocation: prioritizing patients at higher risk
  - Cost Efficiency: Preventing complications can lead to shorter hospital stays and fewer medical interventions