Modeling Sleep Related Physiological Response Variables

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Background

Reference Paper: *SaYoPillow: Blockchain Integrated Privacy Assured IoMT Framework for Stress Management Considering Sleeping Habits*

- E-Textile pillow that measures sleep and physiological variables.
  - hours of sleep, snoring range (dB), respiration rate (bpm), heart rate (bpm), blood oxygen levels, eye movement rate (REM), limb movement rate, body temperature, and stress state
- Generated data will be utilized for machine learning to determine stress level.
  - Experimental data

Goal and Methods

1) Explore dataset given and the nine measured variables
2) Explore relationships between physiological variables
3) Generate a linear regression model for respiration rate

Question: How does sleep related physiological variables relate to each other?

Methods:

- Criterion Based Selection Methods: AIC and BIC
- Multicollinearity: VIF and Condition Constant
- Linear regression model summary: Exploration of p-values

Initial Data Exploration

- Stress is a discrete variable
- hours of sleep, snoring range (dB), respiration rate (bpm), heart rate (bpm), blood oxygen levels, eye movement rate (REM), limb movement rate, and body temperature are continuous variables
- Nonlinearity present between some variables.
    - Stress is discontinuous (Step Function)
- Negative correlations present between some variables

Initial Attempt   (General Linear Model)

- Poisson Regression and Binomial Regression
- Errors present cause of variable property
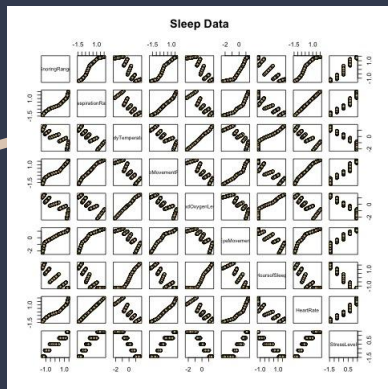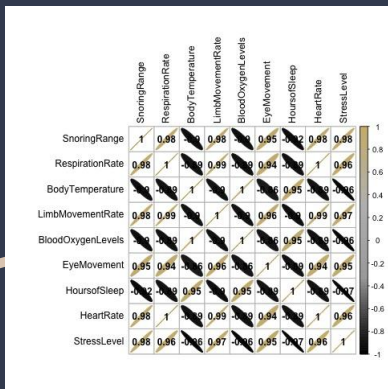
Respiration Model

- Normalized dataset
- Four predictors taken into consideration: Heart Rate, Eye Movement, Limb Movement Rate, and Snoring Range
- Linear Regression Assumptions
  - Linearity: Residuals V Fitted Plot
  - Independence: Durbin Watson Test (p value=0.234) thus no correlations present
  - Normality: QQ Plot
  - Constant Variance: Residuals V Fitted Plot
- General Model Summary
  - P-value of limb movement rate and snoring rate are greater than 0.05
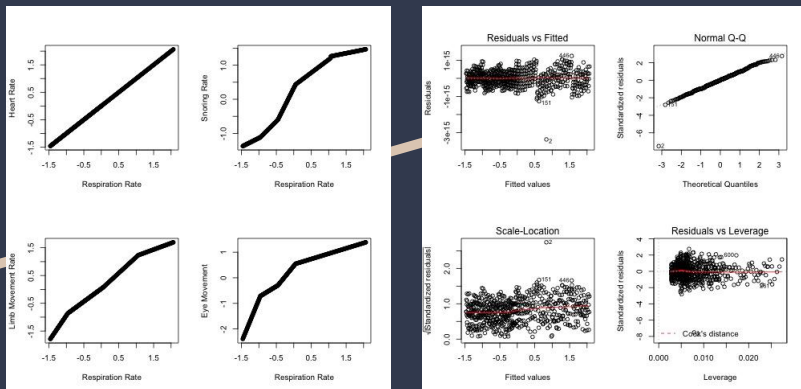
Criterion Based Methods: AIC and BIC
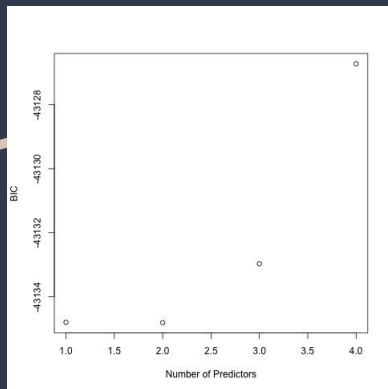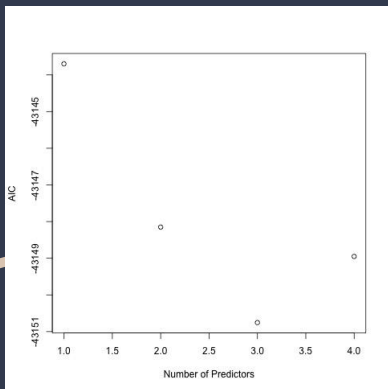
AIC

- Should use three predictors. They are heart rate, limb movement rate, eye movement.
- P-value for limb movement rate is greater than 0.05

BIC

- Should use two predictors. They are heart rate and limb movement rate.
- P value for limb movement rate is greater than 0.05

Both models are insignificant and rely on limited variables.

Multicollinearity: VIF and Condition Number

VIF

- VIF for heart rate is 105.92, the snoring range is 28.44, the limb movement rate is 183.05, and the eye movement rate is 24.86

Condition Number (kappa)

- Constant kappa is 25.60

AIC Adjusted and BIC Adjusted Models both have similar VIF and Kappa values.

Final Model

- Final model will have two predictors. They are heart rate and eye movement.
  - Eye movement p-value is less than 0.05
- VIF for heart rate is 8.01 and for eye movement is 8.01
- Constant kappa is 5.52
- Heavy reliance on heart rate (shown by strong linear relationship in pairs plot)
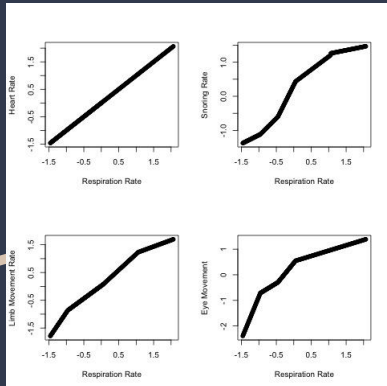
Conclusion and Discussion

- Multicollinearity still present
  - Heart rate and eye movement can be linear combinations of each other
- Model states an error: Regression fit is perfect and summary might be inaccurate
- Clear that all variables utilized in this model have some type of relationship.
  - Heart rate is a significant physiological variable that controls the body's response during sleep, it would be safe to say that the heart rate impacts eye movement, limb movement, and snoring range.
- Importance of thinking about how the variables might be related before performing linear regression
- Exploring and generating a model for stress.
  - Generate a stress variable that is not discrete but continuous.
  - Non parametric methods of modeling: Additive Modeling

Thank You

For any questions, please email

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