Predictive Analytics in Healthcare

HI 743

Department of Health Informatics and Administration
Zilber College of Public Health
University of Wisconsin - Milwaukee

January 23, 2025

Overview

HI 743 - Predictive Analytics in Healthcare

- **Instructor**: Ryan Gallagher
- **Time & Place**: Thursdays 2:30PM - 5:00PM in EH 103
- **Textbooks**: *Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies* by John D. Kelleher, Brian Mac Namee and Aoife D' Arey

  Introduction to Statistical Learning with Applications in R (Second Edition) by Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani
  (Freely Distributed at `statlearning.com`)
- **Required Materials**: Textbook, A Computer (Laptop preferably), R (software), & RStudio (IDE for R)

About Me

Ryan Gallagher

Biostatistician
MCW/CW Advanced Genomics Lab

M.A. in Biostatistics & Data Science (MCW)
B.S. in Statistics & Applied Physics, double major (UWEC)

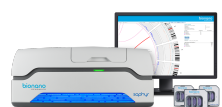
What I Do

- Biostatistics
  - Hypothesis Testing
  - Model Fitting
  - Differential Expression Analysis
- Bioinformatics
  - Pipeline Development
  - Genomic Data Analysis
- Programming
  - R for Statistics
  - Python for Data Processing Pipeline
  - Bash for Linux Cluster

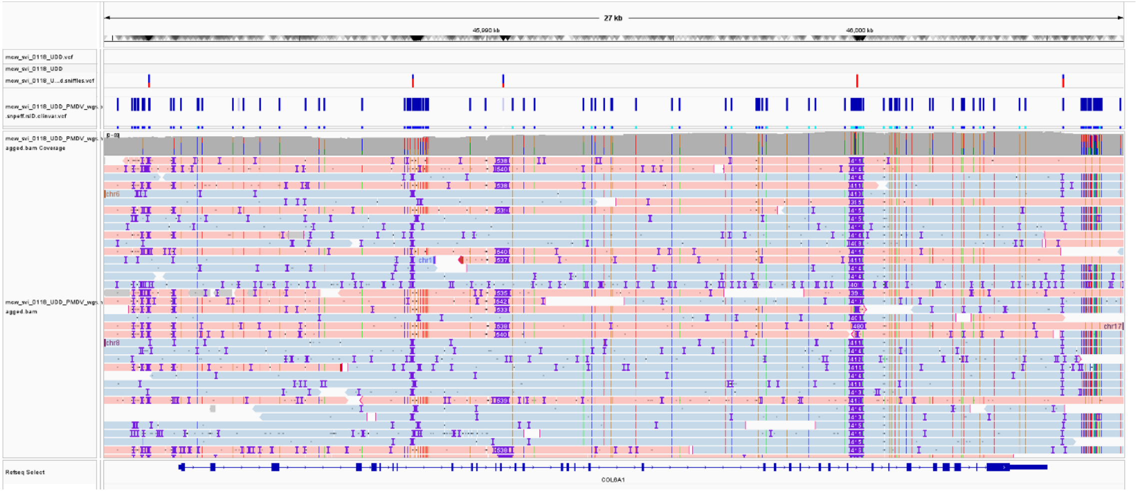
What I Do

I work on my lab's **Structural Variance Initiative**, which:

1. Recruits & Consents Pediatrics Patients
2. Sequences Entire Genome from Biological Sample
   - 2.1 Oxford Nanopore Long-Read Sequencing
   - 2.2 Bionano Optical Genome Mapping
3. Processes Raw Sequencing Reads (Python + Bash)
   - 3.1 Sequencing Data Management ($\sim$ 1.5TB)
   - 3.2 Raw Sequence Alignment + QC
   - 3.3 Identify SNPs + Small INDELs, CNVs, SVs
4. Annotate Identified Variants
5. Identify Potential Disease Causing Variants



What I Do



27 kb
45,990 kb
46,000 kb
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mcw_svi_0118_UDD
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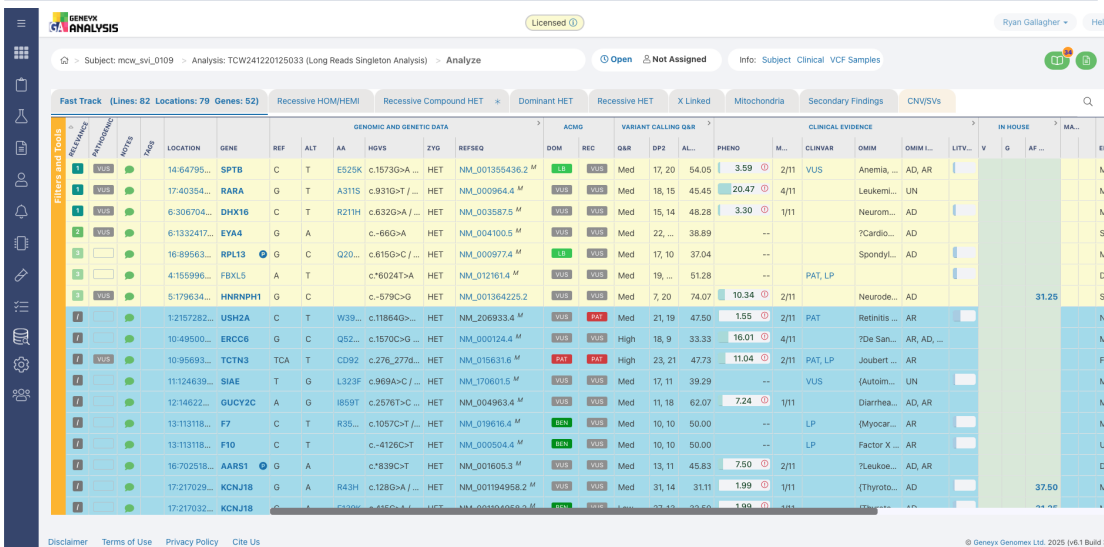
What I Do


GENEVX ANALYSIS
Licensed
Ryan Gallagher
Help
Subject: mcw_svi_0109 > Analysis: TCW241220125033 (Long Reads Singleton Analysis) > Analyze
Open
Not Assigned
Info: Subject Clinical VCF Samples
Fast Track (Lines: 82 Locations: 79 Genes: 52)
Recessive HOM/HEMI
Recessive Compound HET
Dominant HET
Recessive HET
X Linked
Mitochondria
Secondary Findings
CNV/SVs
Filters and Tools
GENOMIC AND GENETIC DATA
ACMG
VARIANT CALLING Q&R
CLINICAL EVIDENCE
IN HOUSE
MA...
RELEVANCE
PATHOGENIC
NOTES
TAGS
LOCATION
GENE
REF
ALT
AA
HGVS
ZYG
REFSEQ
DOM
REC
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DP2
AL...
PHENO
M...
CLINVAR
OMIM
OMIM I...
LITV...
V
G
AF ...
EFFEC
1:64795... SPTB C T E525K c.1573G>A ... HET NM_001355436.2 LB VUS Med 17, 20 54.05 3.59 2/11 VUS Anemia, ... AD, AR Miss
17:40354... RARA G T A311S c.931G>T / ... HET NM_000964.4 VUS VUS Med 18, 15 45.45 20.47 4/11 Leukemi... UN Miss
6:306704... DHX16 C T R211H c.632G>A / ... HET NM_003587.5 VUS VUS Med 15, 14 48.28 3.30 1/11 Neurom... AD Miss
6:1332417... EYA4 G A c.-66G>A HET NM_004100.5 VUS VUS Med 22, ... 38.89 -- ?Cardio... AD Splic
16:89563... RPL13 G C Q20... c.615G>C / ... HET NM_000977.4 LB VUS Med 17, 10 37.04 -- Spondyl... AD Miss
4:155996... FBXL5 A T c.*6024T>A HET NM_012161.4 VUS VUS Med 19, ... 51.28 -- PAT, LP Dow
5:179634... HNRNPH1 G C c.-579C>G HET NM_001364225.2 VUS VUS Med 7, 20 74.07 10.34 2/11 Neurode... AD 31.25 Star
1:2157282... USH2A C T W39... c.11864G>... HET NM_206933.4 VUS PAT Med 21, 19 47.50 1.55 2/11 PAT Retinitis ... AR Non
10:49500... ERCC6 G C Q52... c.1570C>G ... HET NM_000124.4 VUS VUS High 18, 9 33.33 16.01 4/11 ?De San... AR, AD, ... Miss
10:95693... TCTN3 TCA T CD92 c.276_277d... HET NM_015631.6 PAT PAT High 23, 21 47.73 11.04 2/11 PAT, LP Joubert ... AR Fran
11:124639... SIAE T G L323F c.969A>C / ... HET NM_170601.5 VUS VUS Med 17, 11 39.29 -- VUS {Autoim... UN Miss
12:14622... GUCY2C A G I859T c.2576T>C ... HET NM_004963.4 VUS VUS Med 11, 18 62.07 7.24 1/11 Diarrhea... AD, AR Miss
13:113118... F7 C T R35... c.1057C>T / ... HET NM_019616.4 BEN VUS Med 10, 10 50.00 -- LP {Myocar... AR Miss
13:113118... F10 C T c.-4126C>T HET NM_000504.4 BEN VUS Med 10, 10 50.00 -- LP Factor X ... AR Upst
16:702518... AARS1 G A c.*839C>T HET NM_001605.3 VUS VUS Med 13, 11 45.83 7.50 2/11 ?Leukoe... AD, AR Dow
17:217029... KCNJ18 G A R43H c.128G>A / ... HET NM_001194958.2 VUS VUS Med 31, 14 31.11 1.99 1/11 {Thyroto... AD 37.50 Miss
17:217032... KCNJ18 HET NM_001194958.2 BEN VUS Med 1.99
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About You

[Name]
[Program / Area of Focus]
[Aspirations Post Education?]
[Familiarity with Statistics? (Scale 1-10)]
[Familiarity with Programming? (Scale 1-10) (Languages?)]
[Do you have a Laptop? (Which OS?)]

Syllabus

Lets look at our syllabus

Week 2 - Course Motivations

Lecture:

- What is Predictive Data Analytics?
- What is Machine Learning?
- How does Machine Learning work?
- How is Machine Learning relevant to my field of interest?

Week 3 - Intro to R Language

Lecture:

- What is R?
- Why use R?
- Brief History of R

R **Lab:**

- Hands-on Tutorial in R
- Data Manipulation with *Tidyverse* Package
- R Figures

Week 4 - Data Exploration

Lecture:

- Data Quality
- Data Preparation
- Missing Values / Outliers

R **Lab:**

- Hands-On Data Cleaning
- Data Visualization

Week 5 - Error Based Regression

Lecture:

- Simple Linear Regression
- Multiple Linear Regression & Interpretation
- Nonlinear Regression & Interpretation

`R` **Lab:**

- Multiple & Nonlinear Regression
- Interpreting `R` Output
- Introduction to `RMarkdown` for Reporting

Week 6 - Classification / Logistic Regression

Lecture:

- Logistic Regression
- Generalized Linear Models
- Multinomial Logistic Regression

`R` **Lab:**

- Logistic Regression in `R`
- `glm()` function

Week 7 - Case Study (or Classification Continued)

This week will either be a continuation of the Classification methods.

Or

We will look at a case study which applies Classification methods to real-world data.

Project Idea is Due Following Week.

Week 8 - Information Based Learning

Lecture:

- Basics of Decision Trees
- Random Forest, Bagging, Boosting, etc..
- Tree "Pruning"

R **Lab:**

- Fitting Classification Trees
- Fitting Regression Trees
- Bagging Algorithms

Week 9 - SPRING BREAK!

No Class!

Week 10 - Unsupervised / Similarity-based Learning

Lecture:

- Principal Component Analysis
- Clustering Methods
- Challenges of Unsupervised Learning

R **Lab:**

- K-Means Clustering
- PCA Example

Week 11 - Probability / Bayesian Methods in ML

Lecture:

- Bayes' Thoerem
- Naive Bayes Model
- Probability Density Functions

R **Lab:**

- Naive Bayes Worked Examples

Week 12 - Neural Networks and Deep Learning

Lecture:

- What is Deep Learning?
- Single Layer Neural Networks
- Multilayer Neural Networks
- Convolutional Neural Networks

R **Lab:**

- Single, Multi, and Convolutional Neural Networks Applied

Week 13 - Model Evaluation

Lecture:

- Model Performance Measures
- Resampling Methods
- Cross Validation

R **Lab:**

- Validation Set Approach
- Cross-Validation
- Bootstrapping

Week 14 - Practical ML Application

Lecture:

- When to use Machine Learning vs. Typical Methods
- Choosing a Machine Learning Approach
- Matching Approaches to Data

Lab portion will be dedicated to working on Final Project.

Week 15 - Work on Final Project

Classtime will be dedicated to working on Final Project.
Project Due May 9th.