Final Project

CUNY621 – MS in Data Science

Group5, April 21, 2019

Presence of Heart Disease prediction

# Description

With nearly 18MM deaths in 2015[[1]](#footnote-1) , cardiovascular diseases (CVD) are the leading cause of death globally and growing in the developing world[[2]](#footnote-2). CVD is a disease class which includes heart attacks, strokes, heart failure, coronary artery disease, arrythmia, venous thrombosis, and other conditions. About half of all Americans (47%)[[3]](#footnote-3) have at least one of three key risk factors for heart disease: high blood pressure, high cholesterol, and smoking.

CVD’s high mortality rate is particularly poignant as researchers estimate that up to 90% of heart disease deaths[[4]](#footnote-4) could be prevented. Typical means of detection include electrocardiograms (ECGs), stress tests, and cardiac angiograms, all of which are expensive. Risk evaluation screenings require blood samples, which are assessed alongside risk factors like tobacco use, diet, sleep disorders, physical inactivity, air pollution, and others.

There is a need for more efficient, scalable (i.e. cost-effective even in the developing world), and – optimally – non-invasive means of early detection that can trigger medical interventions, prompt preventive care by physicians, and/or engender behavioral change on the part of those prone to or suffering from CVD.

Applying data mining techniques to CVD datasets to predict risk based on existing or easy-to-collect health data could improve healthcare outcomes and mortality rates. Ongoing experimentation has been focused on several datasets[[5]](#footnote-5) (below):

|  |  |
| --- | --- |
| **Database Donor** | **Observations** |
| Cleveland Clinic Foundation | 303 |
| Hungarian Institute of Cardiology | 294 |
| University Hospital, Zurich | 123 |
| Long Beach V.A. Medical Center | 200 |

All of these medical datasets include a relatively small number of observations, which is not uncommon for given the costs of experimental data and privacy risk of observational data. Additionally, the attributes recorded are not consistent between these datasets, making meaningful comparison difficult, and the Hungarian, Swiss, and Long Beach sets are missing many variables. Accordingly, as the most complete of the group, the Cleveland dataset is the most frequently used in data science experimentation.

# DATA

The Cleveland dataset contains 303 observations and 76 attributes in total. However, all published experiments refer to a subset of 14 of these attributes, which are available via the UCI machine learning database[[6]](#footnote-6).

The dataset includes 13 features and 1 target variable. Data science experiments have concentrated on distinguishing the presence of heart disease (with values of 1 through 4) from its absence (a value of 0).

|  |  |  |  |
| --- | --- | --- | --- |
| **Feature** | **Variable** | **Description** | **Type** |
| Age | age | In years | Continuous |
| Sex | sex | Gender | Categorial |
| Chest pain type | cp | Scale of 0 to 4 (typical angina, atypical angina, non-angina pain, asymptomatic) | Categorial |
| Resting blood pressure | trestbps | Diastolic blood pressure in mmHg | Continuous |
| Cholesterol | chol | Serum cholesterol (mg/dl) | Continuous |
| Fasting blood sugar | fbs | Greater than 120mg/dl, value of 0 or 1 | Categorical |
| Resting ECG | restecg | Value of 0, 1, or 2 | Categorical |
| Maximum heartrate achieved | thalach | Maximum heartrate from thallium test[[7]](#footnote-7) | Continuous |
| Exercise-induced angina | exang | Value of 0 or 1 | Categorical |
| Old-peak | oldpeak | ST depression induced by exercise relative to rest [[8]](#footnote-8) | Continuous |
| Slope-peak | slope | Slope of peak exercise ST segment, value of 1, 2, or 3 | Categorical |
| Coronary artery disease | ca | Number of major vessels (0-3) colored by fluoroscopy | Categorical |
| Exercise thallium | thal | Exercise thallium scintigraphic defects, vales of 3 (normal), 6 (fixed defect), or 7 (reversible defect) | Categorial |

# LITERATURE REVIEW

For the purpose of this project proposal we conducted a high-level review of the existing literature. Shouman et al[[9]](#footnote-9) presents an exhaustive review work between 2000 and 2016, detailing a wide range of classification techniques used on the above CVD datasets, including Logistic Regression, Decision Trees, Random Forests, KNN, Naïve Bayes, a variety of Neural Network approaches, Multilayer Perceptron, Support Vector Machines, Associative Classifiers, and others. A smaller but equally diverse range have been applied specifically to the Cleveland dataset, yielding diagnostic accuracy peaking in the mid- to high 80% range. This audit concludes that performance is strongest when more than one technique is integrated, though results vary occur across the literature due to discretization methods and other differences.

Based on this high-level review, we focused on a few pieces of research in particular:

* The aim of Shouman et al’s work is to evaluate a potential low-cost heart disease expert system risk evaluation tool leveraging non-invasive data attributes. This is explored by evaluating the Cleveland dataset alongside another dataset from Canberra not available via the UCI machine learning repository. When constrained to Cleveland’s non-invasive data attributes, the best performance is seen with a combination of age, sex, and resting blood pressure. This line of research also explores integrating K-means clustering with decision tree models to improve accuracy.
* Assari et al’s[[10]](#footnote-10) broader data-mining focus finds that SVM and Naïve Bayes outperform KNN (of K=7) and Decision Tree in terms of accuracy when using 10-fold cross-validation. Its results identify the most important features as chest pain type, exercise thallium, and coronary artery disease.
* Sabay et al[[11]](#footnote-11) seek to assess the application of ML techniques requiring more observations to the Cleveland dataset so improve its generalizability. To that end, a surrogate synthetic dataset is bootstrapped using the Synthpop package in R. Logistic Regression is found to be more accurate and stable than Random Forest and Decision Tree methods, both for the original dataset as well as a 50,000 observation surrogate. An ANN perceptron model built on a 60,000 observation surrogate dataset achieves accuracy and recall above 95%.

# Hypothesis and Discussion

[brief: Then there needs to be a discussion on what the student's hypothesis is and how the student's specific solution will improve or solve the problem.

[for discussion / alignment with group]

Sabay sees strongest results with a logistic model on a bootstrapped n=50k dataset, while Shouman combine KNN + Trees, and Assari gets better performance from SVM and Naïve Bayers.

While neural networks have produced accuracy in the high 90s, interpretable results seem to top out in the high 80s. I don’t think it’s wise to attempt to some high-faluting neural network stuff that we don’t comprehend, so we’ll likely to have settle for not beating previous results in the 80s.

However, we could attempt to synthesize the approaches of preceding (or other) research. Potential avenues of investigation include

* Applying a bootstrap approach (Synthpop) to non-invasive features (sex, age, rbp)
* Predicting based on a non-interpretable through PCA or factor analysis (<https://www.karger.com/Article/Pdf/210449>)
* Inspiration from Kaggle (<https://www.kaggle.com/cdabakoglu/heart-disease-classifications-machine-learning> or <https://www.kaggle.com/ahmadjaved097/classifying-heart-disease-patients>

1. [clean up] Shanthi Mendis; Pekka Puska; Bo Norrving; World Health Organization (2011). [*Global Atlas on Cardiovascular Disease Prevention and Control*](http://whqlibdoc.who.int/publications/2011/9789241564373_eng.pdf?ua=1) (PDF). World Health Organization in collaboration with the World Heart Federation and the World Stroke Organization. pp. 3–18. [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [978-92-4-156437-3](https://en.wikipedia.org/wiki/Special:BookSources/978-92-4-156437-3). [↑](#footnote-ref-1)
2. [clean up] GBD 2015 Mortality and Causes of Death Collaborators (8 October 2016). ["Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015"](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5388903). *Lancet*. **388** (10053): 1459–1544. [doi](https://en.wikipedia.org/wiki/Digital_object_identifier):[10.1016/S0140-6736(16)31012-1](https://doi.org/10.1016%2FS0140-6736%2816%2931012-1). [PMC](https://en.wikipedia.org/wiki/PubMed_Central) [5388903](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5388903). [PMID](https://en.wikipedia.org/wiki/PubMed_Identifier) [27733281](https://www.ncbi.nlm.nih.gov/pubmed/27733281). [↑](#footnote-ref-2)
3. <https://www.cdc.gov/heartdisease/risk_factors.htm> [↑](#footnote-ref-3)
4. [clean up] O'Donnell, MJ; Chin, SL (20 August 2016). "Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study". Lancet. **388** (10046): 761–75. [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier):[*10.1016/S0140-6736(16)30506-2*](https://doi.org/10.1016%2FS0140-6736%2816%2930506-2). [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier) [*27431356*](https://www.ncbi.nlm.nih.gov/pubmed/27431356). [↑](#footnote-ref-4)
5. <http://archive.ics.uci.edu/ml/datasets/heart+disease> [↑](#footnote-ref-5)
6. <http://archive.ics.uci.edu/ml/datasets/heart+disease> [↑](#footnote-ref-6)
7. <https://www.healthline.com/health/thallium-stress-test> [↑](#footnote-ref-7)
8. <https://en.wikipedia.org/wiki/ST_depression> [↑](#footnote-ref-8)
9. Mai Mohammed Abbas Shouman, Prototype Development of a Novel Heart Disease Risk Evaluation Tool Using Data Mining Analysis (March, 2014) [↑](#footnote-ref-9)
10. Assari et al., Int J Econ Manag Sci 2017, 6:3, Heart Disease Diagnosis Using Data Mining Techniques, DOI: 10.4172/2162-6359.1000415 <https://www.omicsonline.org/open-access/heart-disease-diagnosis-using-data-mining-techniques-2162-6359-1000415.pdf> [↑](#footnote-ref-10)
11. Sabay, Alfeo; Harris, Laurie; Bejugama, Vivek; and Jaceldo-Siegl, Karen (2018) "Overcoming Small Data Limitations in Heart Disease, Prediction by Using Surrogate Data," SMU Data Science Review: Vol. 1 : No. 3 , Article 12. Available at: https://scholar.smu.edu/datasciencereview/vol1/iss3/12 [↑](#footnote-ref-11)