



## **Predict Onset of Diabetes**

### **Big Data System Design - Final Report**

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### **Introduction**

The research/development question is to predict based on diagnostic measurements whether a patient has type 2 diabetes using the Kaggle based Practice Fusion Diabetes Classification dataset.

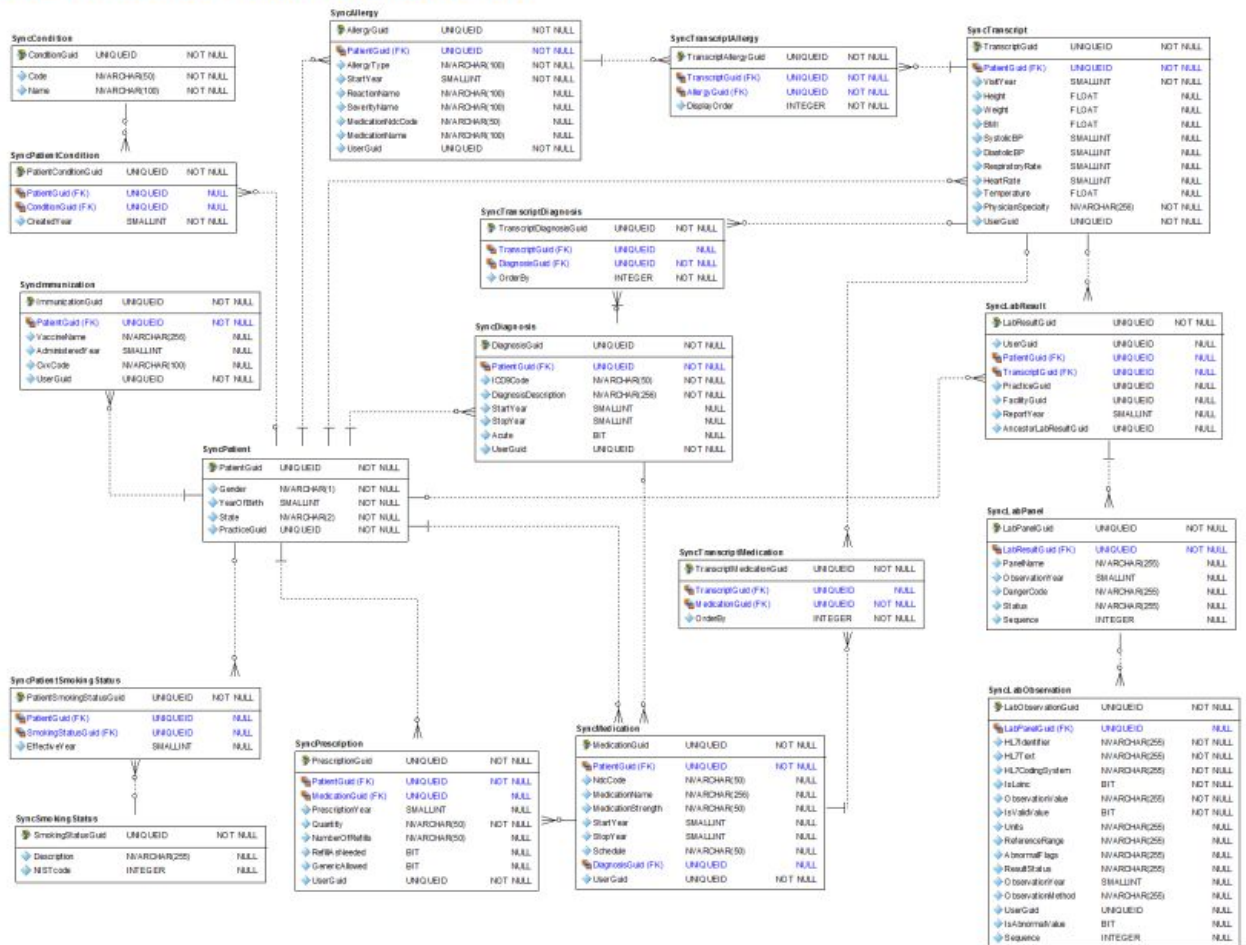
Diabetes can be of type 1 diabetes and type 2 diabetes. 90%-95% of all diabetes cases are Type 2 diabetes which is can be prevented by having healthy eating habits, exercising, and maintaining a healthy weight. Because diabetes is preventable and controllable through lifestyle choices, it is important that patients that are prone to get diabetes are diagnosed as early as possible. One possibility to improving diabetes diagnosing is to use electronic medical records to determine the most important risk factors for diabetes. These risk factors can then be used to find patients with a high risk of getting diabetes to ensure that they are fully evaluated and get preventative treatment. This idea was the reason for the Practice Fusion Diabetes Classification Challenge held from a few years ago.

The Practice Fusion Diabetes Classification Challenge provided a dataset with 10,000 electronic anonymous medical records aimed to build a model that best predicted the probabilities that patients were diagnosed with type 2 diabetes. The large number of records contain detailed patient data on allergy, diagnosis, immunization, lab test, medication, patient statistics, and

other data. The detailed data included Gender, BMI, Height, Weight, SystolicBP, DiastolicBP, RespiratoryRate, HeartRate, Temperature, Meds, Diagnoses, Immunizations, Allergies. A type 2 diabetes diagnosis was defined as having ICD9 codes 250, 250.0, 250.\*0 or 250.\*2 where the asterisk could be any number. Contest entries built their models based on the 10,000 electronic medical records and then were evaluated against 5,000 testing electronic medical records. Our group developed a model for this competition and added a way to allow remote patients to evaluate themselves if diabetes positive based their medical state and contribute to the centralized learning dataset. The Practice Fusion Diabetes dataset had several data types removed in order to make the classification challenge more difficult for the competition. The first modification was to remove patients that have diagnoses for diabetes complications without a basic diagnosis of type II diabetes. The second modification was to remove ICD9 codes 250, 250.0, 250.\*0, 250.\*2, 357.2, and 362.0\*. The third modification was to remove diabetes medications from the medication records. The final modification was to remove lab tests that identified glucose or insulin related tests.

The ultimate goal of your proposed system is to perform this prediction in an automated way using big data system design (MongoDB, Machine Learning, Processing techniques such as Keras, TensorFlow, and Random Forest).

## Practice Fusion De-Identified Data Set



## Motivations

- This is interesting question for us due to a lot of our family members have diabetes
- It is important to develop a system to be able to predict the occurrence of diabetes if the patient's lifestyle and eating habits are kept the same and possibly prevent the occurrence of diabetes if preventative steps are taken by patient
- 415 million people have diabetes worldwide
- 8.3% of the world adult population (equal parts men/women) have diabetes and is rising
- Diabetes doubles a person's risk of early death.
- 5 million deaths occur worldwide each year because of diabetes.
- The global economic cost of diabetes is estimated to be US \$612 billion.

## Related Work

The following are sources of existing research/development work has tried to answer the same or a similar question:

- Data set: <https://www.kaggle.com/c/pf2012-diabetes>
- [Using the ADAP learning algorithm to forecast the onset of diabetes mellitus](#)
- [Developing risk prediction models for type 2 diabetes: a systematic review of methodology and reporting](#)

A highly reliable and accurate automated prediction algorithm is still not available.

Also, it would be self-evident that an accurate automated prediction algorithm should work regardless of gender and ethnic background.

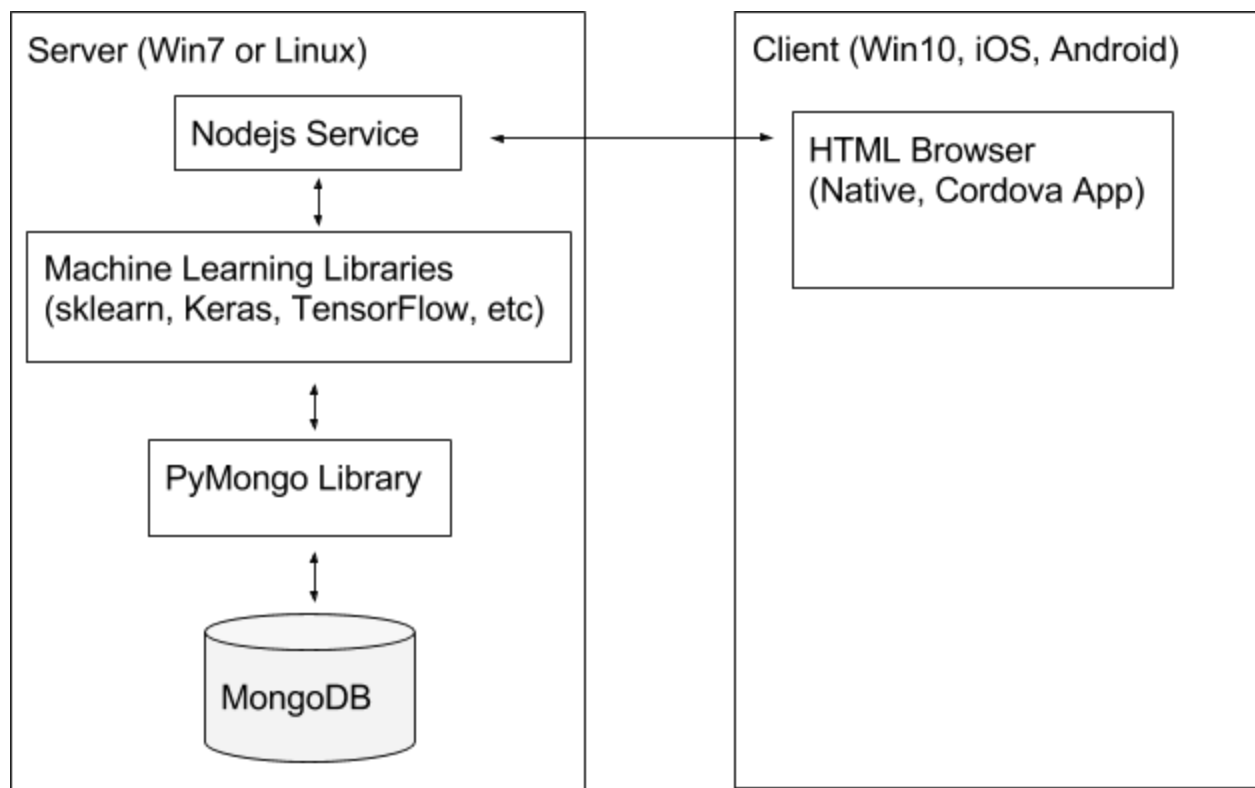
## Proposed Approach

Plan for working out the solutions to the question:

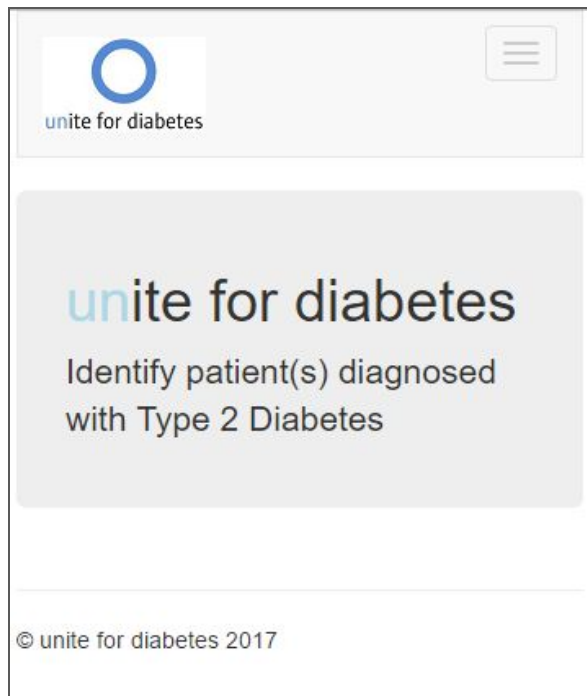
- Research dataset
  - Survey knowledge experts (UML doctor, nursing staff, and people with the diabetes)
  - Improve via algorithms accuracy and precision level on missing values
  - Research ML algorithms, current solutions on kaggle.com
  - Use rapidminer.com, and Python ML libraries
  - Performance test ML algorithms
- Main features in your proposed system:
  - MongoDB (i.e. NoSQL DB), Python, Node.js)
  - Client Application HTML5, JS, Cordova mobile development front end (desktop, iOS, Android)
  - Data entry and/or upload data to add to global learning dataset
  - Matplotlib, plotly, Google Chart, D3, etc.
  - Based on input data, one or more users can be told whether or not he/she has or is susceptible to get type 2 diabetes (data can be optionally added to learning dataset to improve algorithm accuracy)
- Implementation approach:
  - MongoDB
  - Python, RapidMiner, RStudio
  - HTML5, JS, Node.js
  - Evaluated and used: Keras, TensorFlow, Scikit Learn
  - Evaluated Machine Learning Algorithm(s) (Classification, Regression, Clustering, Dimensionality reduction, Model selection, Preprocessing, NN) - those found exhibiting best performance
    - Keras based neural network
    - Random Forest Classifier
    - Gaussian Naive Bayes

- K-Nearest Neighbor Classifier
- Decision Tree Classifier
- After evaluating many ML algorithms, the following was settled on:
  - Random Forest Model - using the “scikit learn” python library
  - Keras for use as a high-level neural networks API, with TensorFlow - low-level neural networks API
  - Features used to : Age, Gender, BMI, Height, Weight, Systolic Blood Pressure, Diastolic Blood Pressure, Respiratory Rate, Heart Rate, Temperature, Medications, Diagnoses, and Lab Tests

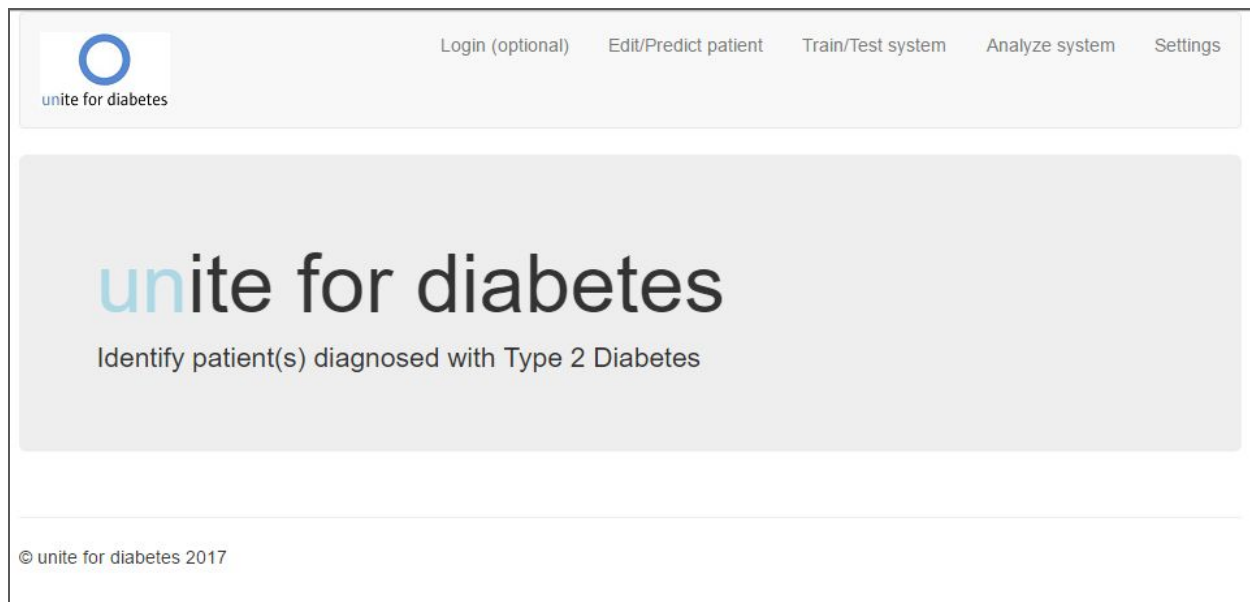
#### System Block Diagram





## Mobile Application



## Tablet/Desktop Application



## Application Screens



### Edit/Predict patient

**Gender:**

Male ▼

**BMI:**

Enter value

**Height:**

Enter value

**Weight:**



Enter value

**Systolic BP:**

Enter value

**Diastolic BP:**

Enter value



### Settings



**Machine learning algorithm:**

Random Forest ▼

Random Forest

Neural Network



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### Train/Test system

Train/Test system

© unite for diabetes 2017



### Analyze

Diabetes Positive

-

Random Forest Model

Accuracy: 0.82

Log Loss: 0.38

Processing time: 3757 sec (62 min)

-

Neural Network

Accuracy: 0.76

Log Loss: 0.62

80 epochs

Processing time: 2761 sec (46 min)

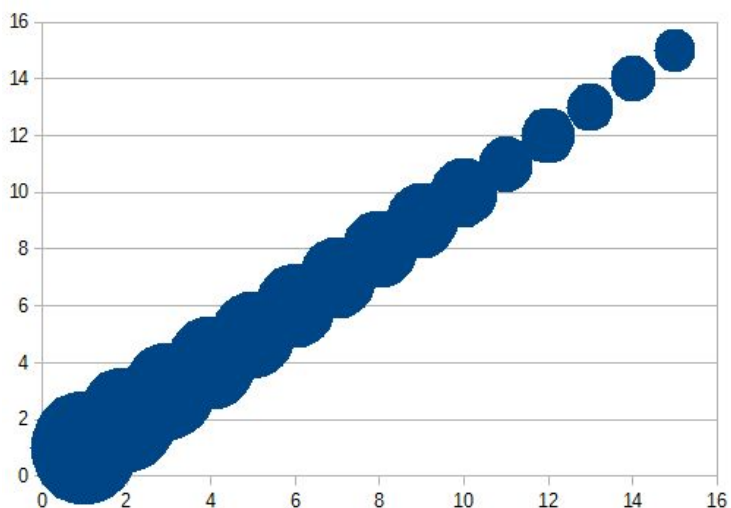
## Evaluation

We evaluated our solution as follows (to demonstrate that our solution/answer is good/reasonable):

- Test ML algorithms locally with the stock dataset
- Preprocess dataset
- Find the algorithm that performs the best in a reasonable amount of processing time at a small scale first. Used Anaconda and Jupyter notebook extensively.
- Setup a MongoDB environment to handle the increase in size
- Integrate MongoDB component
- Test the scaled up components at the backend server side
- Test the scaled up components at the client side
- For Random Forest and NN, train on the training dataset, then test the test dataset
- Compare all results with those available online in previous studies
- Publish results on sites like github and kaggle.com to verify and respond to feedback

Dataset feature importance factors to determine diabetes positive (sorted high to low) after reading online medical documentation and preprocessing. It was interesting to find that the most important feature factors that where medications were related to heart disease. This finding by the model agrees with medical documentation that shows type 2 diabetes is associated with a higher risk of coronary heart disease.

Patient-YOB, Patient-BMI, Patient-Weight, Patient-SystolicBP, Patient-DiastolicBP, Diag-Melenoma, Patient-Height, Patient-Temperature, Diag-Int-Pain, Diag-Resp, Diag-HeartValve, Med-Lisinopril, Diag-Osteoarthritis, Diag-Dysphonia, Patient-Gender, Diag-HeartCongenital, Med-Simvastatin, Med-Lipitor, Med-Zocor, Diag-HeadInjury, Diag-Carcinoma, Diag-Carcinoma, Diag-Hyperhidrosis, Diag-Hyperhidrosis, Diag-Dysphagia, Med-Cozaar, Diag-Mastodynia, LabTestAuthorized, Diag-Colitis





Using the Random Forest Model ([https://en.wikipedia.org/wiki/Random\\_forest](https://en.wikipedia.org/wiki/Random_forest)), ground truth was pre-defined in the dataset for this challenge based on if a patient had ICD9 codes 250, 250.0, 250.\*0 or 250.\*2. The asterisk could be any number. The features were fit to the random forest model using 5,000 trees in the forest and the ground truth of whether or not each patient had diabetes.

Once the model was trained, electronic medical records from the test patients were used to test the model. The goal of the model was to predict the probability between 0-100% that a patient had a diabetes diagnosis. The prediction from the model for each patient's data was compared to the ground truth using a log loss formula to quantify the performance of the model. The log loss was the primary quantification used to evaluate the models in this competition.  $N$  is the number of patients,  $\log$  is the natural logarithm,  $\hat{y}_i$  is the posterior probability that the  $i$ th patient has diabetes, and  $y_i$  is the ground truth where  $y_i = 1$  indicates diabetes and  $y_i = 0$  indicates no diabetes.

$$\text{log loss} = -\frac{1}{N} \sum_{i=1}^N y_i \log(\hat{y}_i) + (1 - y_i) \log(1 - \hat{y}_i),$$

where  $N$  is the number of patients,  $\log$  is the natural logarithm,  $\hat{y}_i$  is the posterior probability that the  $i^{\text{th}}$  patient has diabetes, and  $y_i$  is the ground truth ( $y_i = 1$  means the patient has diabetes,  $y_i = 0$  means that he does not).

## Timeline

- Week 1 (ending 2017-02-02) - Proposal presentation
- Week 2 (ending 2017-02-09) - Pre data set analysis and Github setup
- Week 3 (ending 2017-02-16) - Subject matter expert surveys, topic research
- Week 4 (ending 2017-02-23) - ML algorithm analysis
- Week 5 (ending 2017-03-02) - ML algorithm testing
- Week 6 (ending 2017-03-09) - ML algorithm testing
- Week 7 (ending 2017-03-16) - MongoDB integration
- Week 8 (ending 2017-03-23) - MongoDB integration
- Week 9 (ending 2017-03-30) - Front end development
- Week 10 (ending 2017-04-06) - Front end development
- Week 11 (ending 2017-04-13) - System performance testing (train/test)
- Week 12 (ending 2017-04-20) - System performance testing (train/test)
- Week 13 (ending 2017-04-27) - Final presentation/report

## Experimental Results and Discussions

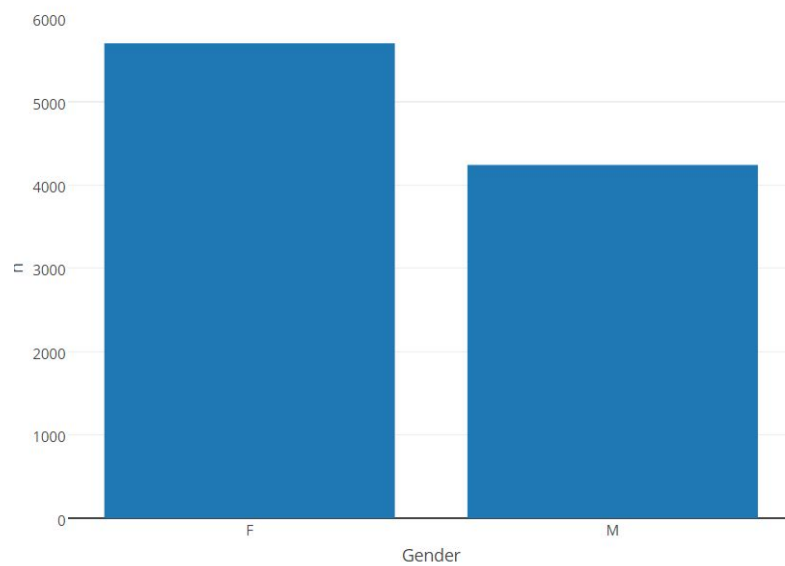
### *Random Forest Model*

- Accuracy: 0.82
- Log Loss: 0.38
- Processing time: 3757 sec (62 min)

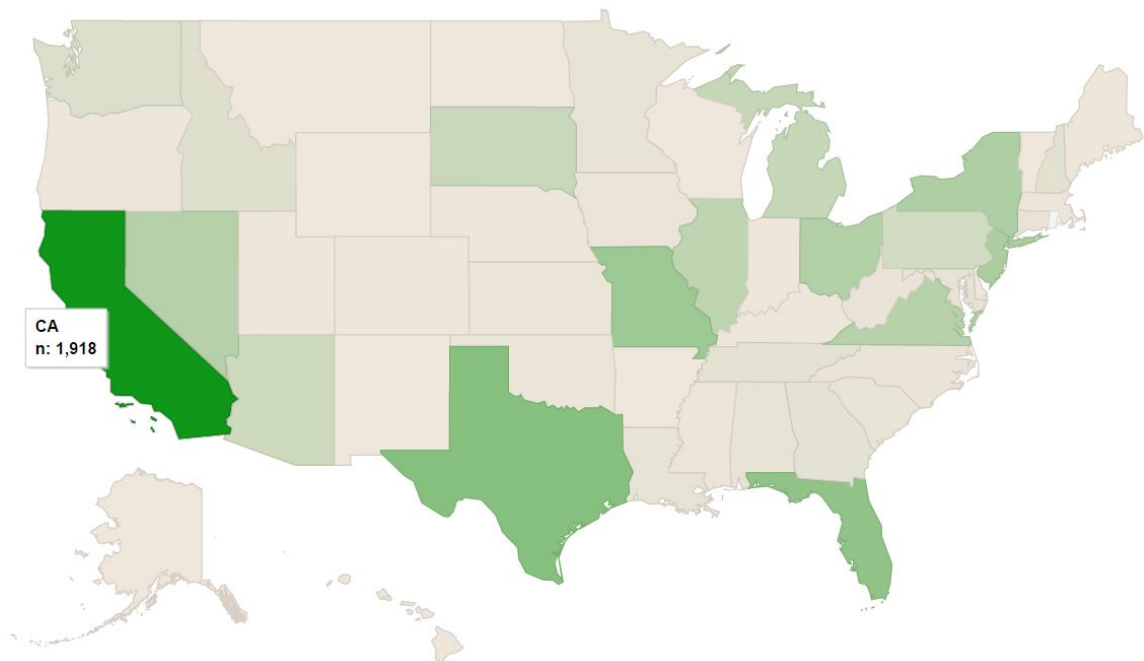
### Decision Tree Classifier Investigation (using R)

<http://www.rpubs.com/janakiram/add>

#### Diabetes Positive by Gender



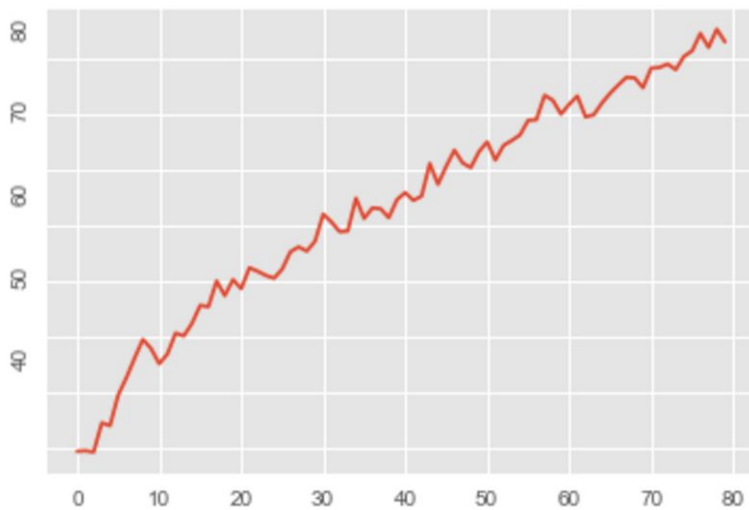
## Diabetes Positive by State



## Keras/TensorFlow Model

- Accuracy: 0.76
- Log Loss: 0.42
- 80 epochs

## Accuracy improvement over epochs



## Conclusions and Future Work

- Conclusion:
  - Our solutions were competitive against other teams who entered the Kaggle based Practice Fusion Diabetes Classification dataset contest (our best log loss 0.38, contest range 0.31 - 0.60)
  - Feature importance values corresponded with literature
- Future Work:
  - Overall, the model was a success, but there is room to improve the accuracy of prediction.
  - Use of GPUs to speed performance (local or remote third party (AWS))
  - Publish Diabetes predictor app to iOS, Android, Windows stores and public website to allow users determine likelihood of diabetes and/or to add their medical records to help train and improve accuracy of model
  - Partner with a government agency to help distribute app to promote healthier lifestyles

## References

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[3] Deep Learning with Python by Jason Brownlee

<https://machinelearningmastery.com/deep-learning-with-python>

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<https://keras.io>

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<http://scikit-learn.org>

[6] MongoDB - NoSQL database

<https://www.mongodb.com>

[7] PyMongo - MongoDB API

<https://api.mongodb.com/python/current>

[8] Cordova - HTML5 based Cross Platform Mobile App platform

<https://cordova.apache.org>

[9] American Diabetes Association. Economic costs of diabetes in the U.S. in 2012. *Diabetes Care* April 2013. 36(4):1033-1046

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3609540/>

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<https://www.cdc.gov/diabetes/pdfs/newsroom/diabetes-materials-for-study-or-distribution-by-health-care-professionals.pdf>

[11] Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, Marks JS. Prevalence of obesity, diabetes, and obesity-related health risk factors. *JAMA*. 2003; 289(1):76-79.

<https://www.ncbi.nlm.nih.gov/pubmed/12503980>

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[13] Haffner S, Lehto S, Ronnema T, Pyorala K. Mortality from Coronary Heart Disease in Subjects with Type 2 Diabetes and in Nondiabetic subjects with and without prior Myocardial Infarction. *N Engl J Med*. 1998; 339:229-234

<http://www.nejm.org/doi/full/10.1056/NEJM199807233390404#t=article>