Machine Learning in Hospital Billing Management

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Introduction

The purpose of the described study is to advance healthcare provider operations and performance through improved healthcare administration, management and operations through the use of machine learning methods to improve billing. Across the country, healthcare providers are experiencing ongoing pressure from declining revenues. Payers are under increasing pressure to contain costs. The implementation of healthcare reform through the Patient Protection and Affordable Care Act (Public Law 111-148) will further exacerbate this issue. These and additional demands to combat waste, fraud and abuse are creating mounting pressures to achieve 'perfection' in all phases of healthcare billing and reimbursement authorization for hospitals and independent healthcare providers such as physicians and medical group practices. In order to ensure that payments are appropriate, payers must ascertain that there is proper documentation of care prior to reimbursement. Providers must be diligent in maintaining proper documentation to receive the correct payment and avoid a loss of revenue.

Methods

The opposing pressures of payers and providers call for the use of decision support/screening methods, to better manage the billing and revenue cycle and detect inconsistencies in coverage, care/service documentation and payments, and to guide financial and clinical personnel through this process. Specifically, we are using machine learning to create models for screening billing information for inconsistency. The initial, proof-of-concept, study presented here is based on batch processing of obstetrics data collected from a one year period in 2008.

In the first step, the data is pre-processed to match requirements of the machine learning application used. Data available in multiple tables in the hospital information system need to be converted into a flat file. Additional processing of variables needs to be done. In the second step, the AQ21 machine learning system (Wojtusiak et al., 2006), which creates predictive models in the form of highly transparent attributional rules is used. In order to apply the application to create models the data is classified as “normal payment” and “abnormal payment” that correspond to payments consistent and not consistent with contractual agreements, respectively. Finally, after the rule-learning phase, the models are used to predict if a specific bill is likely to receive normal payment in advance to its submission to payer.

Results and Conclusion

Initial application of the method to analyzing billing information for obstetrics patients covered by Medicaid gave very promising results. The presented method presents two strong benefits in analyzing billing information. First, the use of machine learning allows to automatically create models for predicting payments of bills before their submission. The models allow screening of billing information before it is sent to payers, therefore maximizing chances of full payments, and reducing unnecessary denials. Second, the use of highly transparent representation of models in the form of attributional rules, allows for detection of regularities in bill denials which may lead to potential workflow improvement.

Reference

Wojtusiak, J., Michalski, R. S., Kaufman, K. and Pietrzykowski, J., "The AQ21 Natural Induction Program for Pattern Discovery: Initial Version and its Novel Features," *Proceedings of The 18th IEEE International Conference on Tools with Artificial Intelligence*, Washington D.C., November 13-15, 2006.

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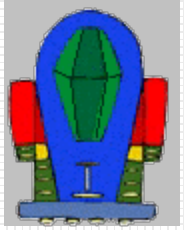
Part 1: Introduction



Introduction

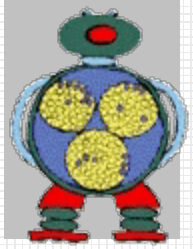
- Healthcare providers experiencing declining revenues
- Payers are under increasing pressure to contain costs
- The implementation of healthcare reform through the Patient Protection and Affordable Care Act (Public Law 111-148) increases the financial pressures.

Introduction

- The US healthcare system consumes as much as $210 billion annually on claims processing (AMA 2010)
- As much as one in five claims processed inaccurately
- Mounting demand for perfection in documentation and revenue cycle management for hospitals and physicians.

Introduction

- One important problem concerns disparity between filled claims for medical bills and payments received
- Because of the problem complexity, there is a need for modern computational methods to help prepare and handle provider billing
- This study explores using machine learning to discover patterns in claims' payments and use them to better prepare future claims.



Part 2: Why Machine Learning?

Machine Learning

- Machine Learning is a field which concerns developing learning capabilities in machines
- Machine Learning plays central role in artificial intelligence
- Machine Learning integrates results from disciplines such as statistics, logic, data mining, cognitive science, computer science, robotics, pattern recognition, neuroscience, and many others.

What is Learning?

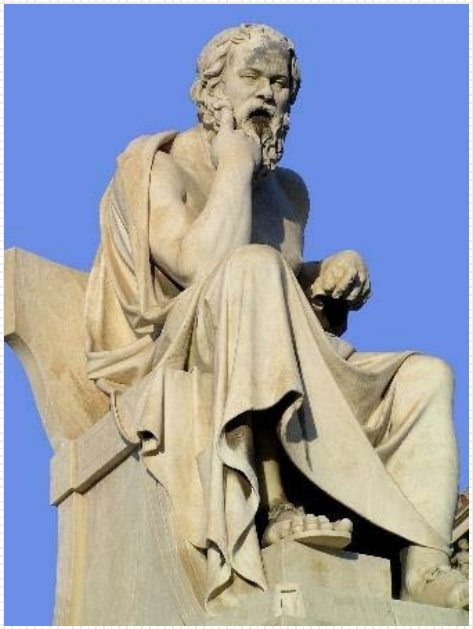
- A computer system learns if it improves its performance or knowledge due to experience, or it adapts to changing environment.

Some Interrelated Fields

- **Machine learning** is concerned with developing learning capabilities in computers, experimentally testing the developed systems, and applying them to practical problems. Most research has been concerned with achieving high classification accuracy through empirical learning. Machine learning is one of the central areas of Artificial Intelligence, and is a parent of other areas
- **Data mining and knowledge discovery** (briefly, KDD—from knowledge discovery in data) concentrates on developing practical and efficient methods for determining useful patterns in large volumes of data. It is a separate field, with its own conferences and journals
- **Knowledge mining** is related to all the fields above, but places its main emphasis on developing methods and systems for deriving human-oriented knowledge from databases and prior knowledge. Databases can be large or small.

Important Aspects of Machine Learning

- Accuracy
- Background knowledge
- Incremental learning
- Representation of knowledge/models
- Understandability of knowledge/models.



Natural Induction

- The idea of "natural induction" has evolved from observation that people are reluctant to accept decisions of a computer if they do not understand principles and conditions under which this decision is suggested decision
- By natural induction is meant an inductive inference process that strives to produce hypotheses that appear **natural to people**, that is, are **easy to understand** and interpret, **easy to relate to past knowledge**, and **directly expressible in natural language** (that is, inductive learning systems that satisfy the principle of comprehensibility)
- Natural induction systems are desirable for many applications of machine learning, such as decision making, data mining and knowledge discovery, advisory systems, planning, etc.

Why Machine Learning in Healthcare?

- Automated processes – machine learning allows automation of complicated processes in healthcare that are not possible using standard computational methods
- Decision support – systems that support decision makers should not be static, but adapt to users, be able to gather new knowledge, recognize new situations, and learn from own and others' experience
- Analysis of large datasets – machine learning opens the possibility to analyze very large datasets that is not possible to do using standard tools
- Analysis of small datasets – it is also important to be able to detect regularities in rarely occurring events.

Building Predictive Models vs. Traditional Studies

- Traditional healthcare studies – hypothesis testing
- Checking relationships between variables – usually correlating variables with each other, building regression models, etc.

- Machine learning can be used to build models that classify new cases -- it is hypothesis generation.

Decision Support

- Decision support system is a computer software that helps in decision making activities

- Machine learning can be applied to answer two important questions in regard to decision support:
  - Where the knowledge come from?
  - How to adapt (to users, changing environment, etc.)?

Rules

An important form of attributional rules is:

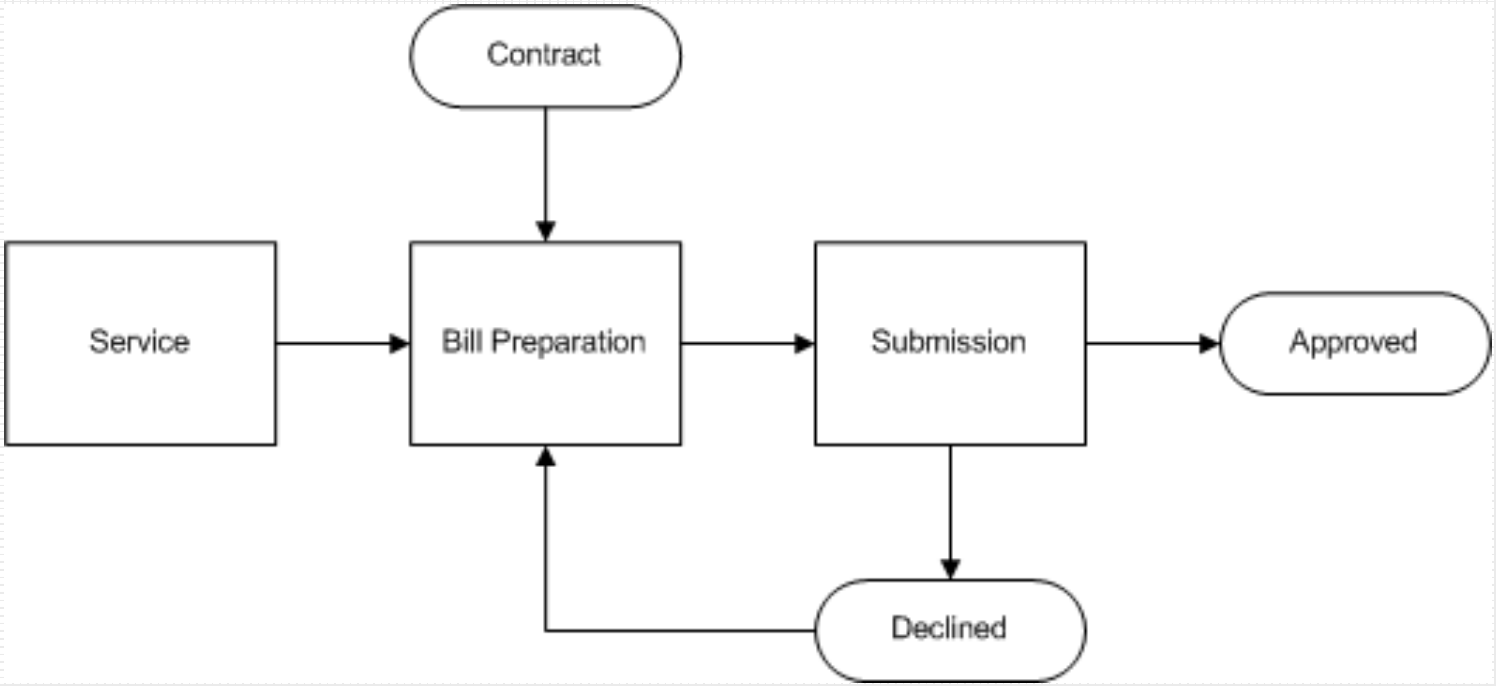
CONSEQUENT <= PREMISE |_ EXCEPTION

where CONSEQUENT, PREMISE AND EXCEPTION (optional) are conjunctions of attributional conditions (a.k.a. selectors):

[L rel R : A]

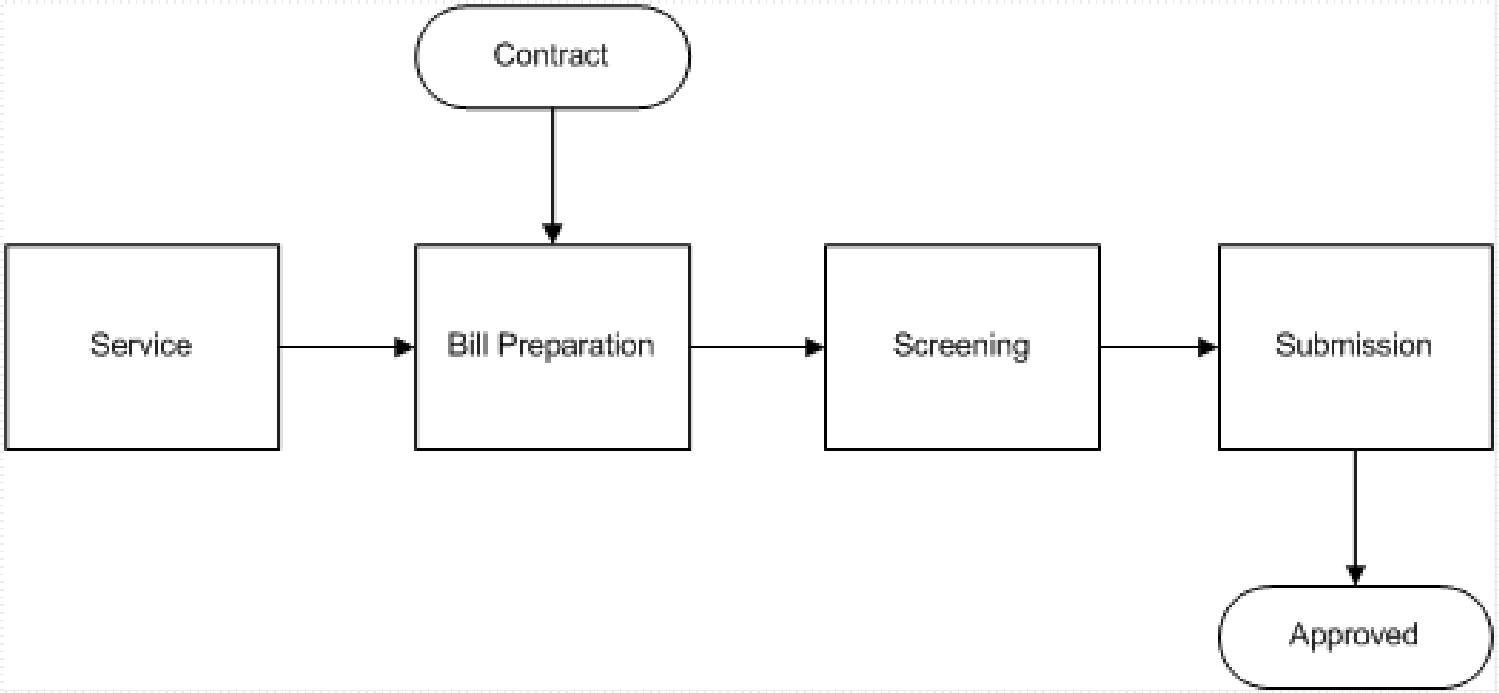
Part 3: Predicting Billing Payments

Bills Processing



- The goal is to develop a prototype software that will detect documentation revenue cycle discrepancies based on hospital billing and clinical care documentation against individual payer criteria for reimbursement.

Bills Processing



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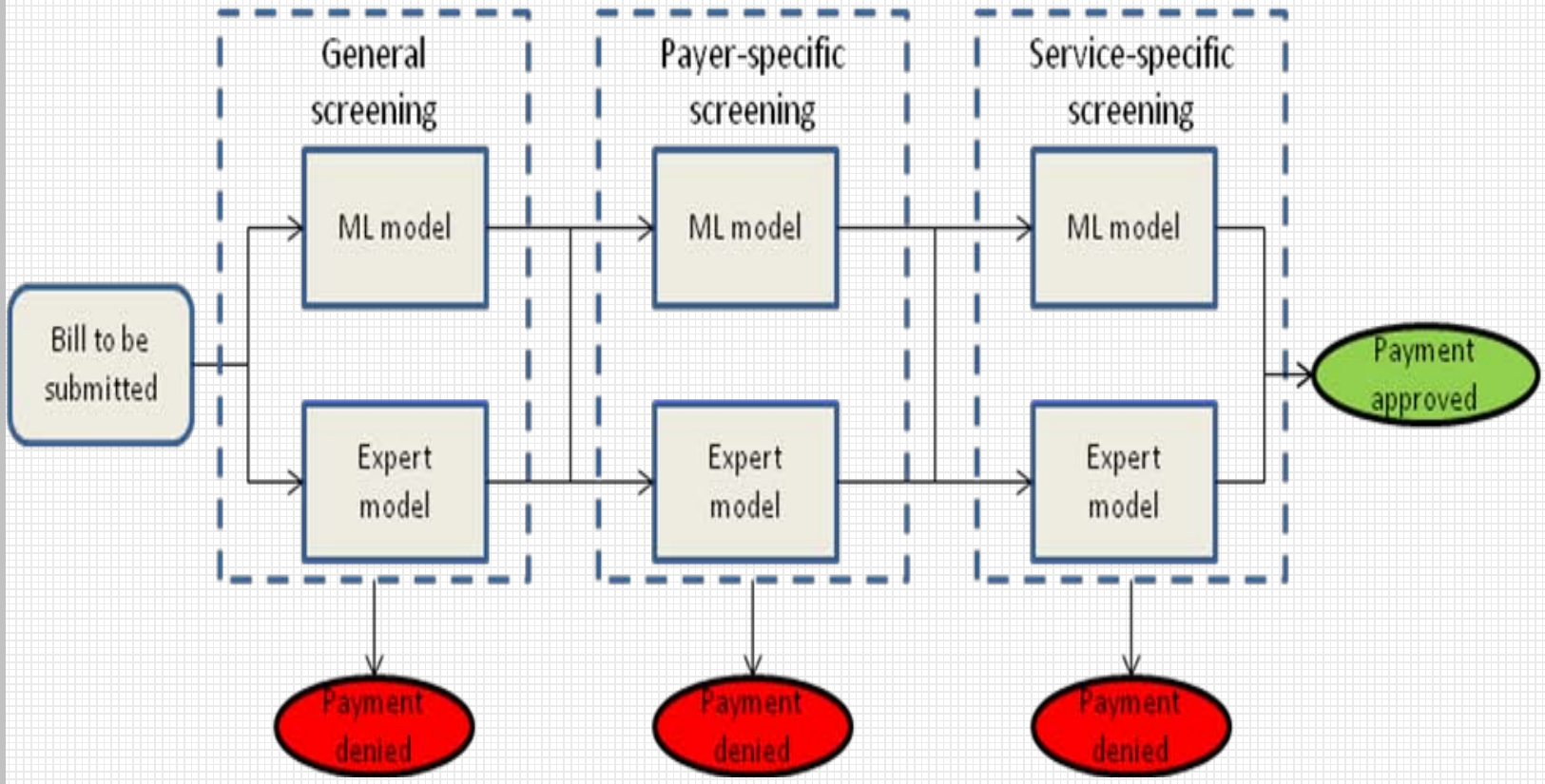
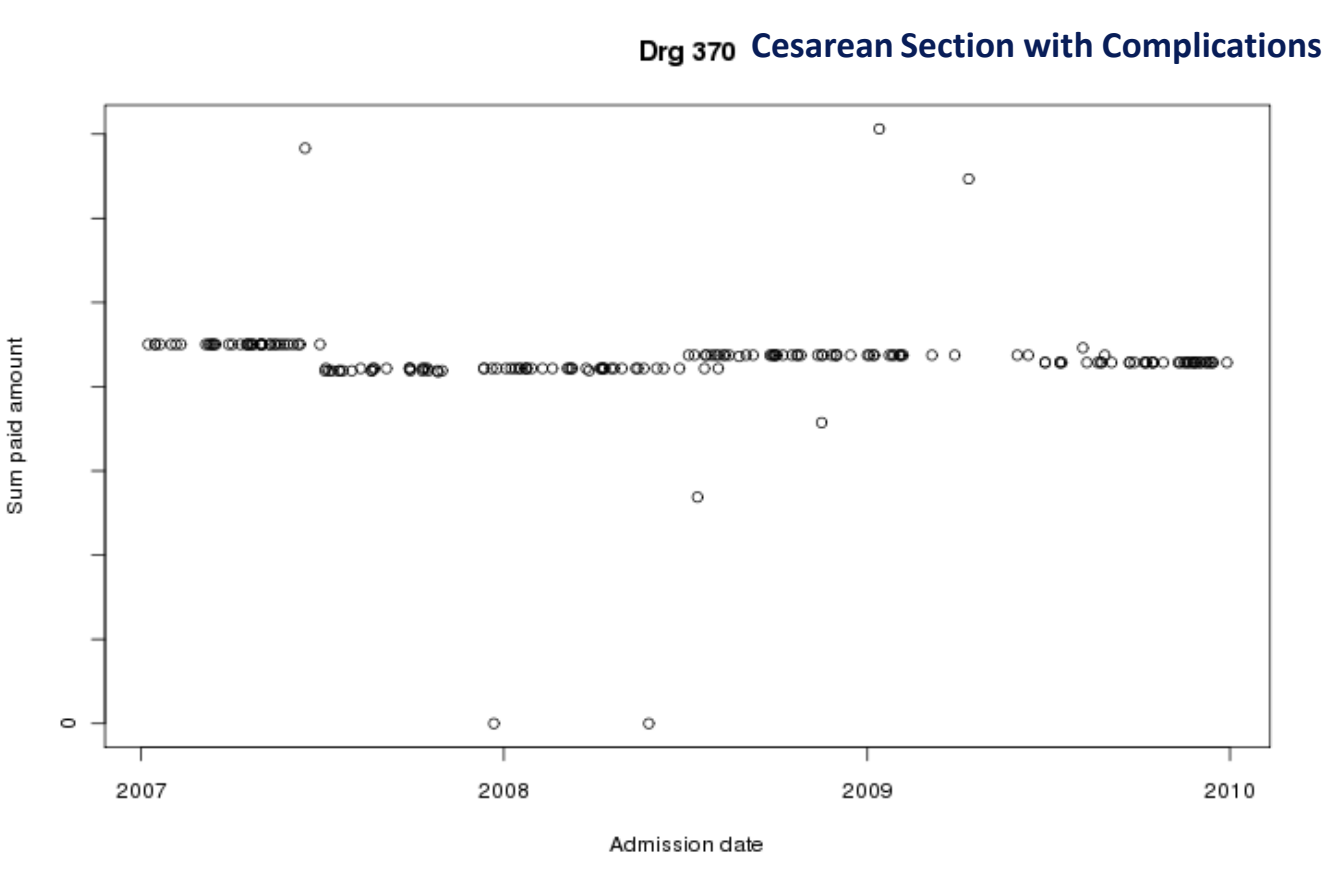
Building Models for Payment Prediction

- Based on historical data models are created to classify bills as
  - Overpaid
  - Paid correct amount
  - Partially paid
  - Not paid
- The models can then be used to screen bills before submission
- Additionally, patterns can be detected for systematic underpayment or lack of payment, i.e., due to discrepancy in contract interpretation, errors in processing.

Screening Process



Example Payments



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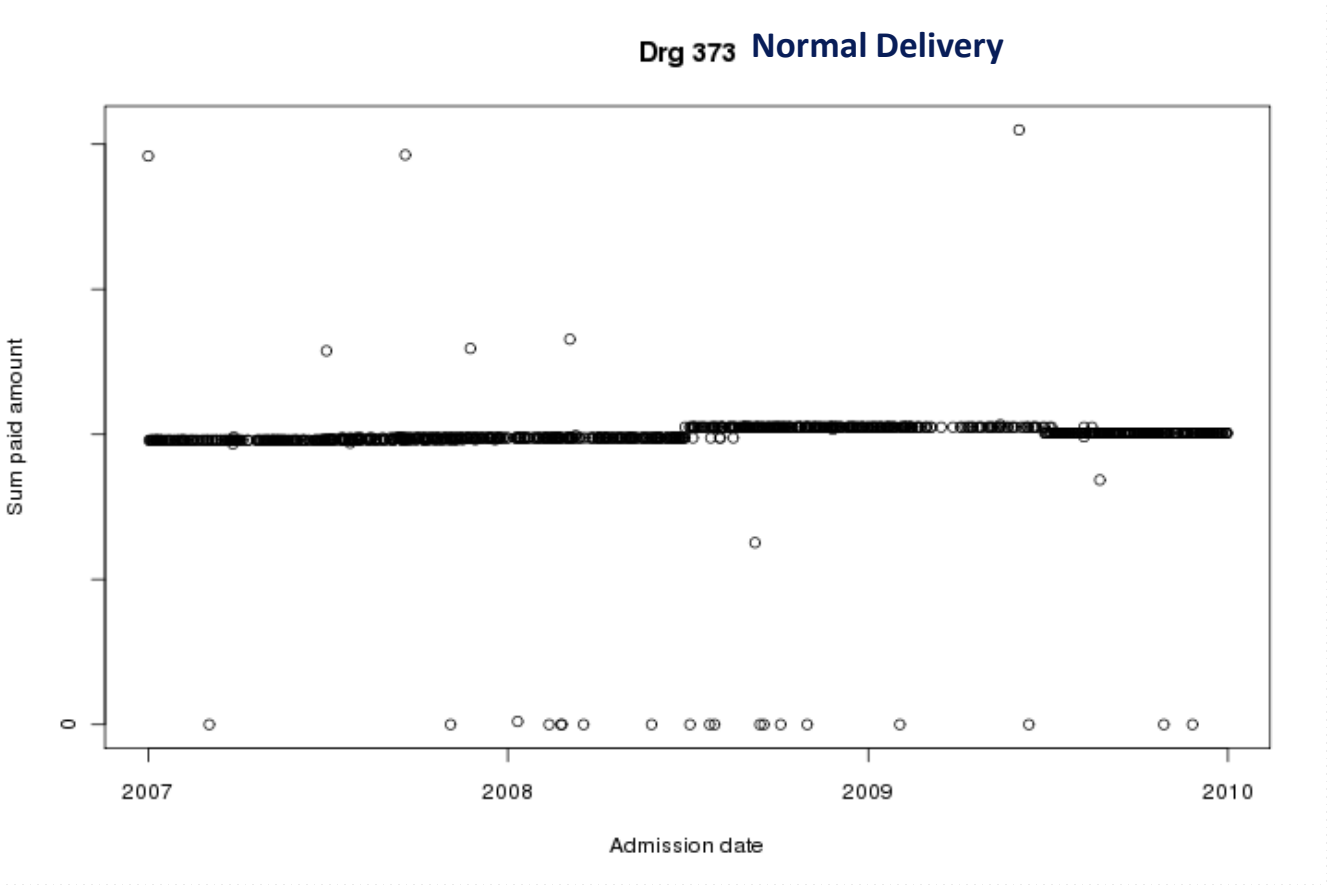


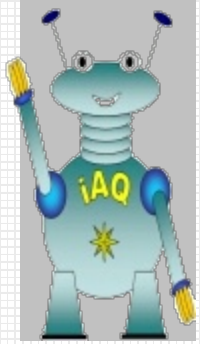
Initial Results

- Initial results on a very limited dataset show about 65% accuracy
- The learned models are, however, oversensitive and classify more bills as unpaid than needed.

Future Work

- The work continues …

Image source:
http://mrnaveen.blogspot.com/



Part 5: Questions?

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