Railway Scheduling using Reinforcement Learning

by Arpit Singh (111601031)

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Scheduling Problem

- **Resources** - Network Topology, Stations, Tracks.
- **Train Movement** - Reference timetable (desired arrival and departure time of each train at each station)
- **Goal** - Assign track resources for each train for a fixed time period, such that they all complete their journeys without conflicts.
- Timetable may be **infeasible**.
  - Adjust arrival and departure times such that all rules are satisfied, while minimizing **Priority Weighted delay**.
- **Rescheduling** online counterpart.
  - **Goal** : Recover from a disruption of timetable (due to delays or faults)

What is Machine learning?
Why do we need to care about machine learning?

- Machine learning (ML) is a category of algorithm that allows software applications to become more accurate in predicting outcomes without being explicitly programmed. The basic premise of machine learning is to build algorithms that can receive input data and use statistical analysis to predict an output while updating outputs as new data becomes available.

- Writing software is the bottleneck, we dont have enough good developers. Let the data do the work instead of people. Machine learning is the way to make programming scalable.

- Machine Learning is getting computers to program themselves. If programming is automation, then machine learning is automating the process of automation.

Growth of Machine Learning

- Machine learning is preferred approach to
- Speech recognition, Natural language processing
- Computer vision
- Medical outcomes analysis
- Robot control
- Computational biology
- Improved machine learning algorithms
- Improved data capture, networking, faster computers
- Software too complex to write by hand
- New sensors / IO devices

Applications of Machine Learning
Sample applications of machine learning:

The value of machine learning technology has been recognized by companies across several industries that deal with huge volumes of data. By leveraging insights obtained from this data, companies are able work in an efficient manner to control costs as well as get an edge over their competitors. This is how some sectors / domains are implementing machine learning -

- Financial Services
- Marketing and Sales
- Government
- Healthcare
- Transportation
- Oil and Gas

Sample application of Machine Learning

Financial Services

Companies in the financial sector are able to identify key insights in financial data as well as prevent any occurrences of financial fraud, with the help of machine learning technology. The technology is also used to identify opportunities for investments and trade. Usage of cyber surveillance helps in identifying those individuals or institutions which are prone to financial risk, and take necessary actions in time to prevent fraud.

Marketing and Sales

Companies are using machine learning technology to analyze the purchase history of their customers and make personalized product recommendations for their next purchase. This ability to capture, analyze, and use customer data to provide a personalized shopping experience is the future of sales and marketing.

Government

Government agencies like utilities and public safety have a specific need FOR MI, as they have multiple data sources, which can be mined for identifying useful patterns and insights. For example sensor data can be analyzed to identify ways to minimize costs and increase efficiency. Furthermore, ML can also be used to minimize identity thefts and detect fraud.

Healthcare

With the advent of wearable sensors and devices that use data to access health of a patient in real time, ML is becoming a fast-growing trend in healthcare. Sensors in wearable provide real-time patient information, such as overall health condition, heartbeat, blood pressure and other vital parameters. Doctors and medical experts can use this information to analyze the health condition of an individual, draw a pattern from the patient history, and predict the occurrence of any ailments in the future. The technology also empowers medical experts to analyze data to identify trends that facilitate better diagnoses and treatment.

Transportation

Based on the travel history and pattern of traveling across various routes, machine learning can help transportation companies predict potential problems that could arise on certain routes, and accordingly advise their customers to opt for a different route. Transportation firms and delivery organizations are increasingly using machine learning technology to carry out data analysis and data modeling to make informed decisions and help their customers make smart decisions when they travel.

Oil and Gas

This is perhaps the industry that needs the application of machine learning the most. Right from analyzing underground minerals and finding new energy sources to streaming oil distribution, ML applications for this industry are vast and are still expanding.

Classification: Applications

- Aka Pattern recognition
- Face recognition: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- Character recognition: Different handwriting styles.
- Speech recognition: Temporal dependency.
- Use of a dictionary or the syntax of the language.
- Sensor fusion: Combine multiple modalities; eg, visual (lip image) and acoustic for speech
- Medical diagnosis: From symptoms to illnesses
- Web Advertizing: Predict if a user clicks on an ad on the Internet.

Main Application

- Face Recognition
- Prediction: Regression
- Regression Applications

Types of Learning?

- Supervised Learning: Uses
- Unsupervised Learning
- Reinforcement Learning

Supervised Learning: Uses

Prediction of future cases
Use the rule to predict the output for future inputs

Knowledge extraction
The rule is easy to understand

Compression
The rule is simpler than the data it explains

Outlier detection
Exceptions that are not covered by the rule, e.g., fraud

Unsupervised Learning

- Learning what normally happens
- No output
- Clustering: Grouping similar instances
- Other applications: Summarization, Association Analysis.

Example applications

- Customer segmentation in CRM
- Image compression: Color quantization
- Bioinformatics: Learning motifs

Reinforcement Learning

- No supervised output but delayed reward
- Policies: what actions should an agent take in a particular situation.Utility estimation: how good is a state (used by policy)
- Credit assignment problem (what was responsible for the outcome)

Applications

- Game playing
- Robot in a maze
- Multiple agents, partial observability, ...

The End