Realistic knowledge-based waiting times for radiotherapy patients

Addressing the pain of waiting

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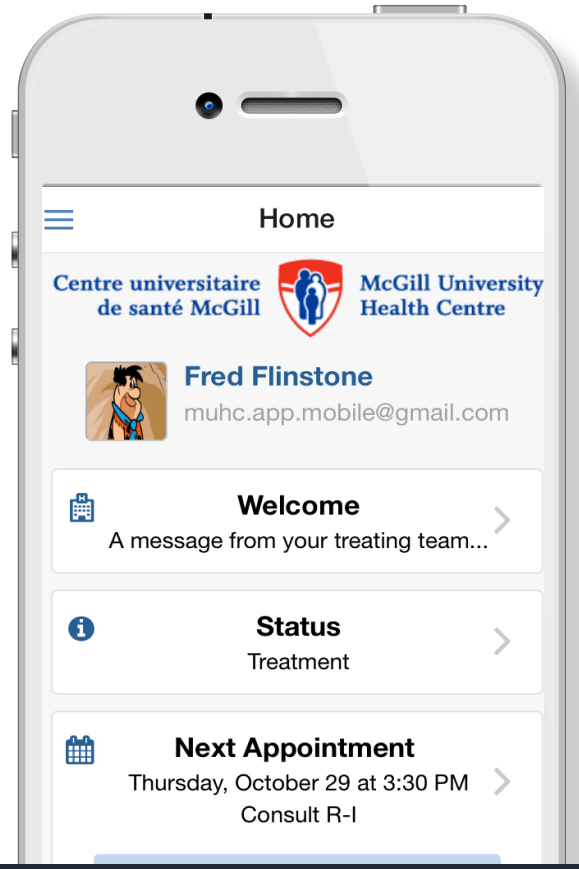
HIG

Personalized Data

Servicing a way for patients to know about their health; all in one central location

Communication

Leverage feedback between patient and doctor



Innovative

Applying modern technology to medicine

Waiting Time Estimates

Reduce waiting uncertainties to improve workflow and increase patient satisfaction

Patient & Doctor App

Realistic knowledge-based waiting times for radiotherapy patients – addressing the pain of waiting

Winners of Q+ Challenge 2014

The problem?

Waiting…

…when there are other things that can be done.

Patients experience…
… 3 different types of waiting in radiation oncology

1. Treatment planning
   - Waiting at home by the phone
   - Can last days to weeks

2. Daily-fractionated treatments
   - Waiting in the waiting room
   - Can last minutes to hours

3. Consultations with physician
   - Waiting in the waiting room
   - Can last minutes to hours

- Difficult for staff to predict.
- Only rough estimates are given based on experience.

Can we build an algorithm to accurately predict how long a patient is expected to wait?

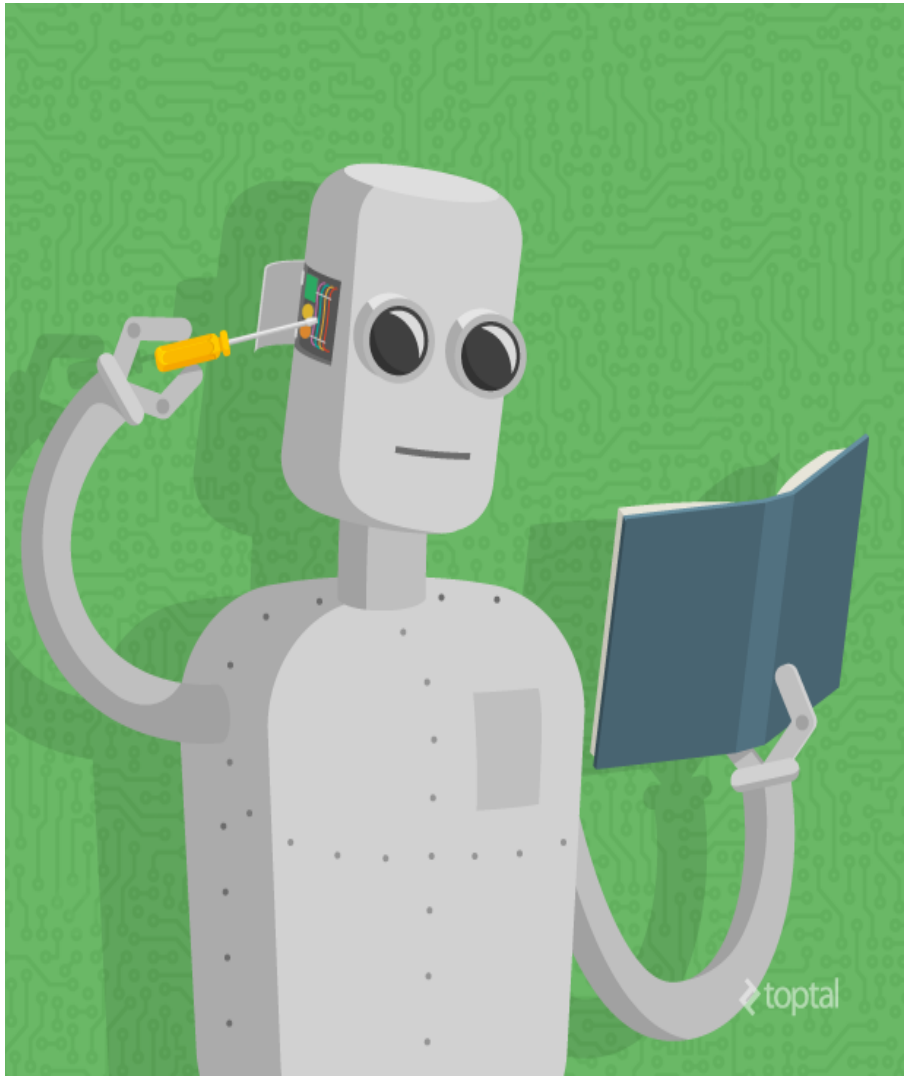
Solution: Machine learning

- **Goal:** To provide radiotherapy patients with **personalized predictions** regarding how long they will wait for the provision of care in the Department of Radiation Oncology at the MUHC

- **How:** Learn data from previous patients to make predictions for future patients.

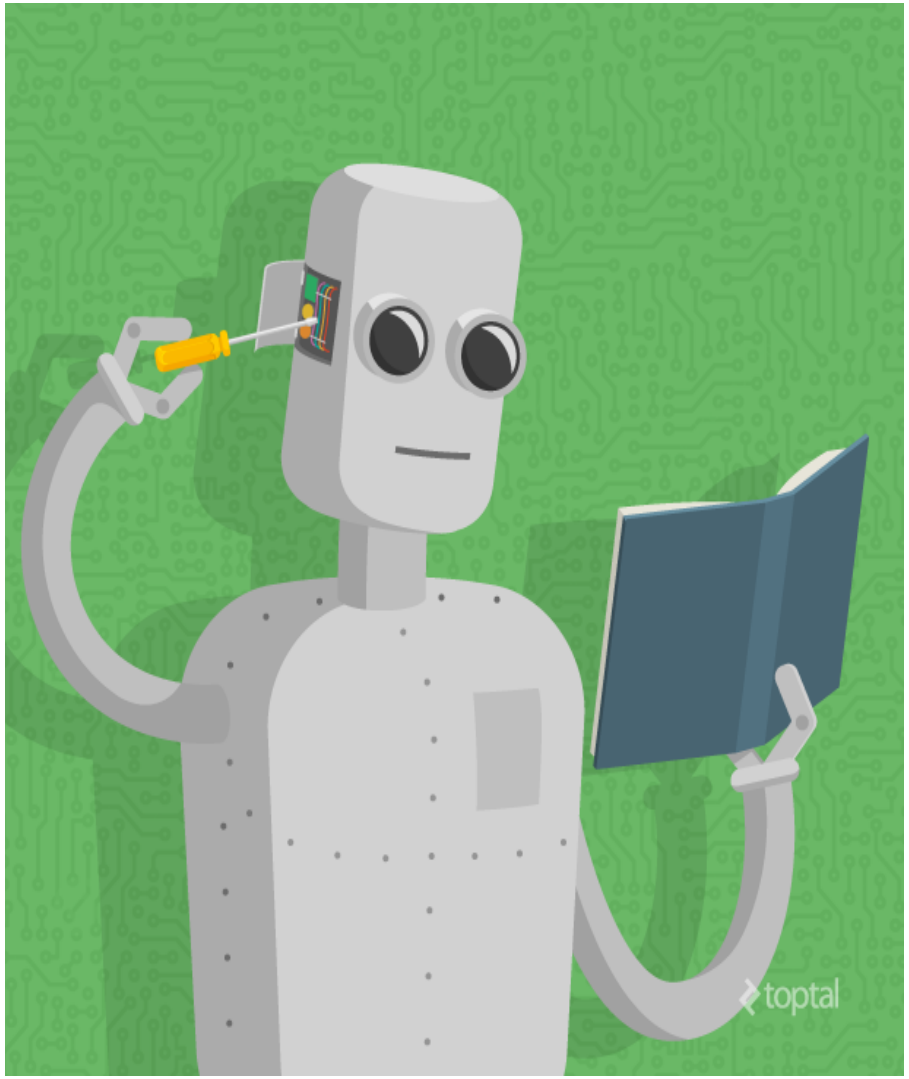
What is machine learning?

- Subfield of Artificial Intelligence
- **Learning:** Any process by which a system improves from experience
- **Machine Learning:** Written computer programs that automatically improve their performance through experience
- They are programs that can **learn** from **data**



Why machine learning?

- Develop systems that can automatically adapt themselves to individual users
  - Personalized information
- Discover new knowledge from large databases
  - Data mining, correlations (ex: beer and diapers)
- Mimic human thought-process to replace monotonous/laborious tasks
- Tackle systems that are too complex to construct analytically
  - Dynamic program instructions (ex: human brain)

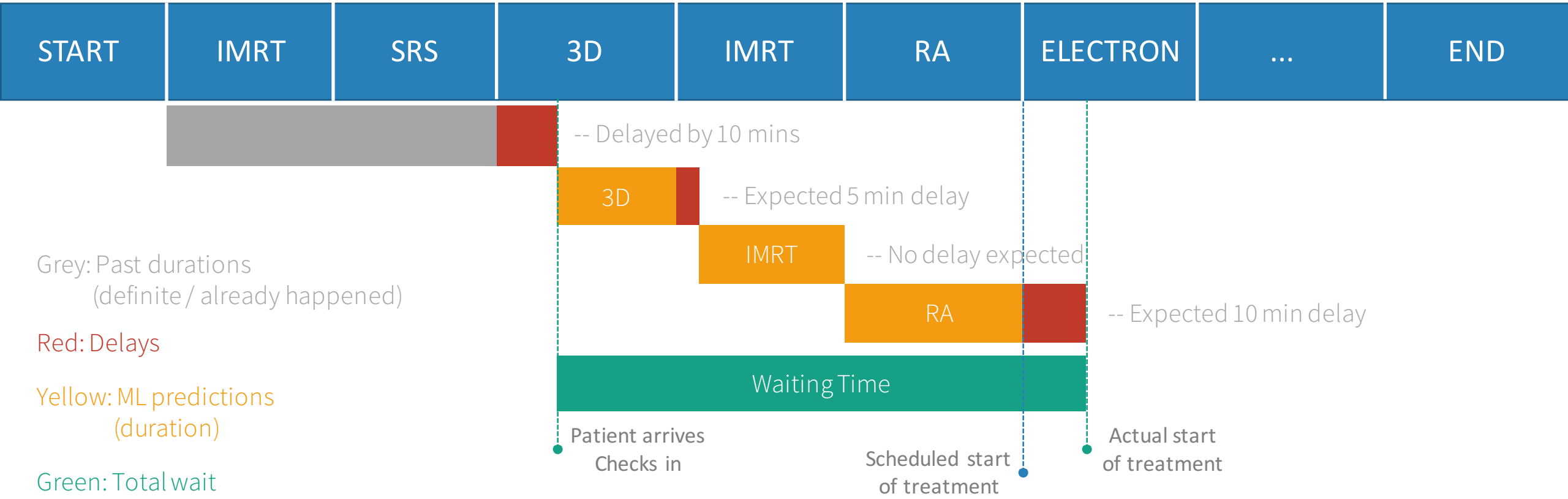


How does ML work?

1. Define the problem
   - **Not knowing how long to wait.**
2. Define your dataset
   - **Putting in historical patient information such as:**
     - Time of the appointment, doctor, diagnosis, etc.
   - **Getting out the duration of an appointment to infer a waiting estimate.**
3. Choosing the right algorithm
   - **There is no perfect model; only a model that is good enough.**
4. Validate your algorithm
   - **Divide your existing dataset into training and testing sets.**
   - **Cross-validate.**

Appointment Timeline

On a typical treatment day for a particular resource



Grey: Past durations
(definite / already happened)

Red: Delays

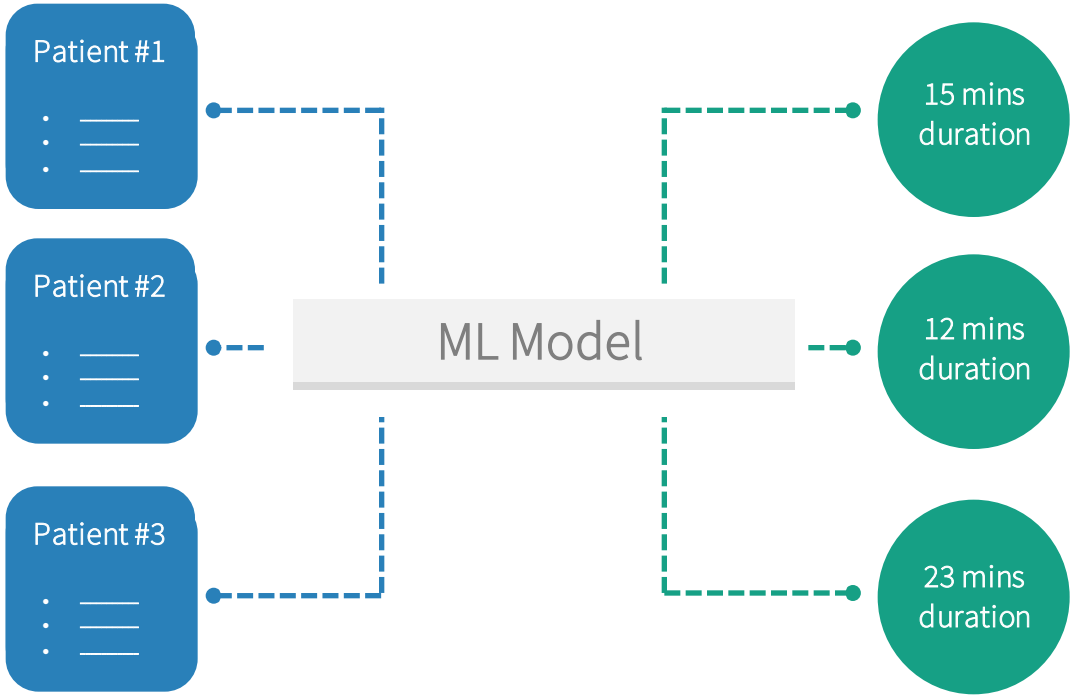
Yellow: ML predictions
(duration)

Green: Total wait

Blue: Treatment type

Defining features

Traits that can explain appointment delays



Input (Vector)

Output (Real Number)

Patient

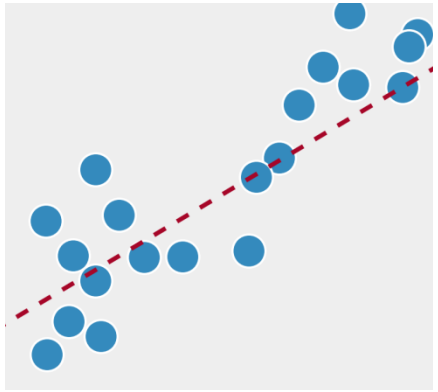
- Diagnosis
- Oncologist
- Treatment machine
- Age
- Day of the week
- Hour of the day
- Month
- Plan
- # of treatment fields
- Fraction number

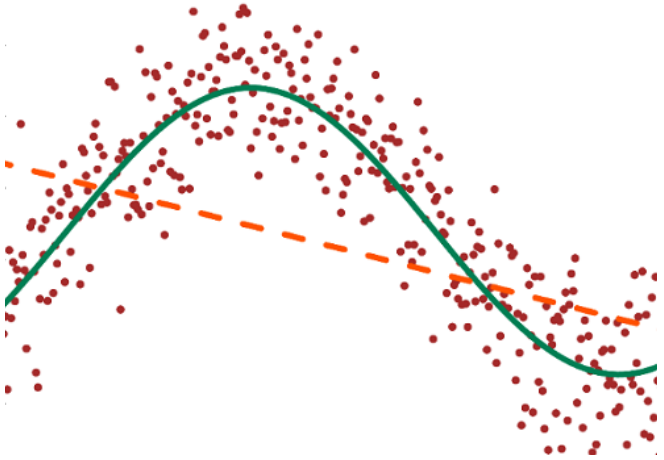
Machine Learning Model

- **ML relates closely to mathematical optimization theory**
- **Cost function for building a model**
- **Training means solving:**

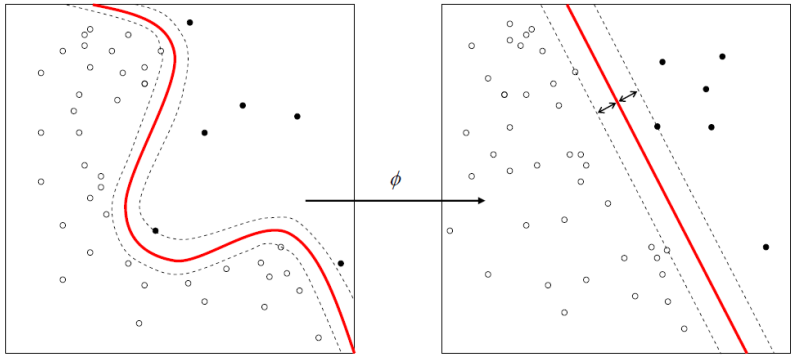
$$\text{minimize } \frac{1}{2}\|w\|^2$$

$$\text{subject to } \begin{cases} y_i - \langle w, x_i \rangle - b \leq \epsilon \\ \langle w, x_i \rangle + b - y_i \leq \epsilon \end{cases}$$



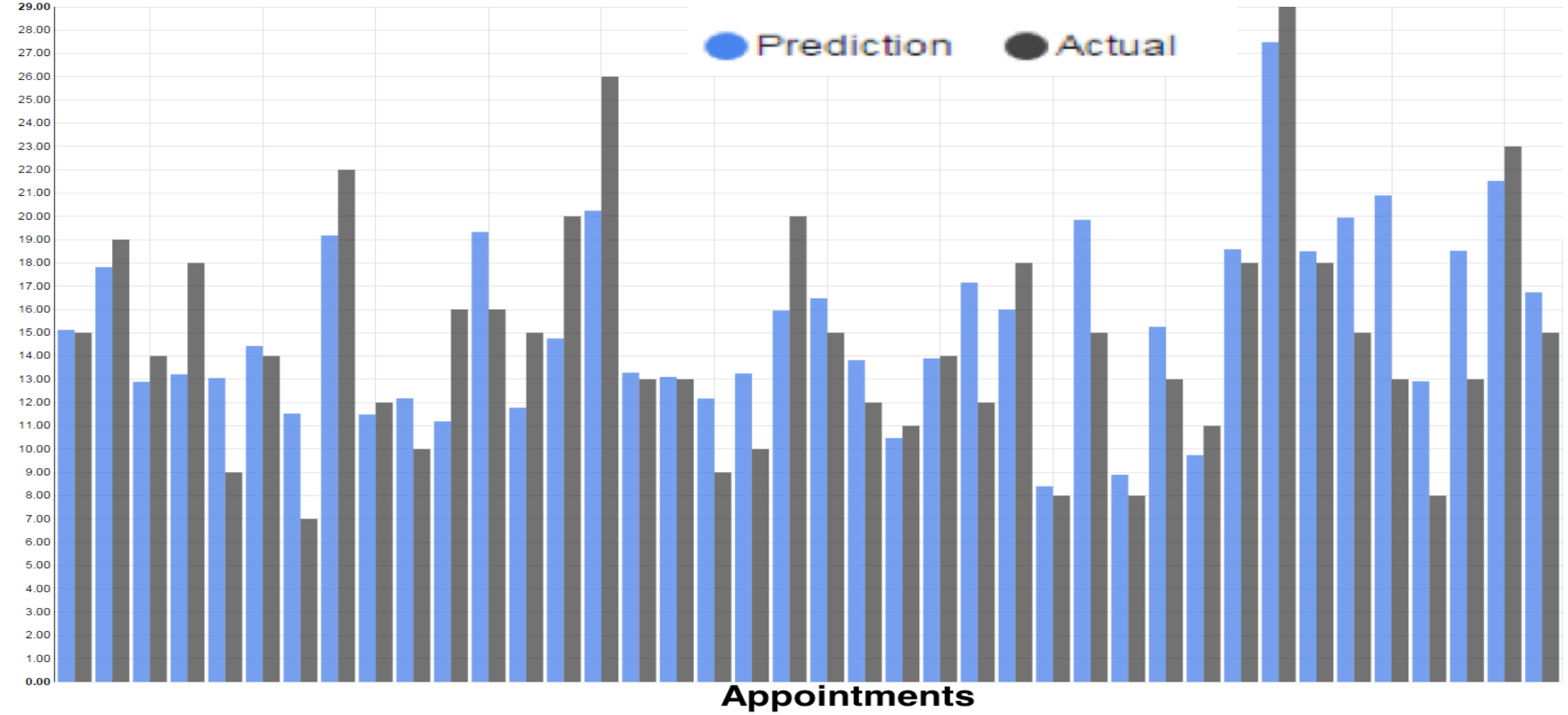


- **In non-linear space, kernel functions are applied to transform feature space to linear space (Kernel trick)**



- **Replace x_i with $\varphi(x_i)$ – Polynomial, Gaussian, Hyperbolic**

Results


Prediction
Actual
29.00
28.00
27.00
26.00
25.00
24.00
23.00
22.00
21.00
20.00
19.00
18.00
17.00
16.00
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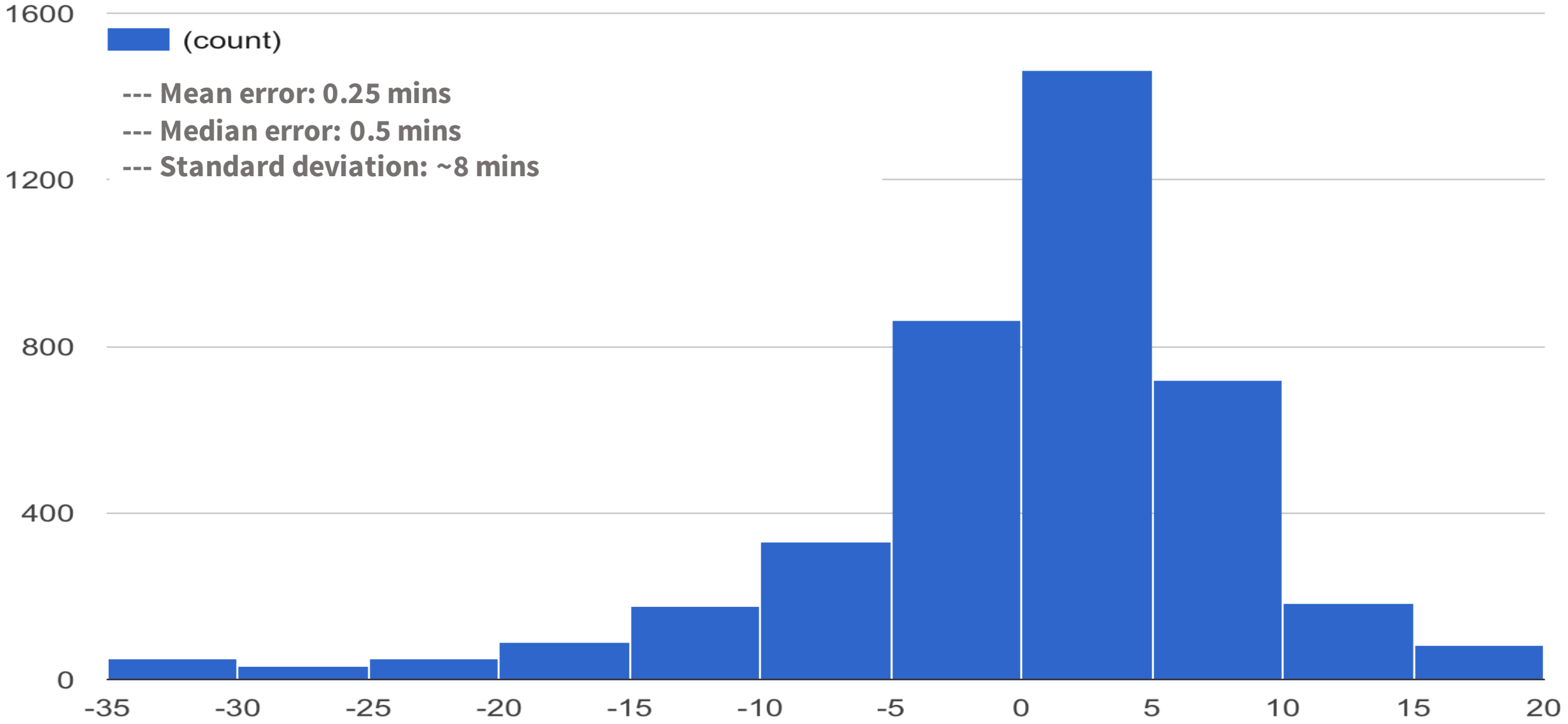
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Appointments

Results

Residual histogram



Conclusion

- **Machine learning can be successfully applied to waiting times in Radiation Oncology.**
- **Future work**
  - **Feature analysis (correlations, patterns)**
  - **Algorithm tuning (optimization parameters)**
  - **Exploring the code (Python scripts)**
  - **Communicate waiting times to patients (patient app)**
  - **Gather feedback from patients**
- **This can have a significant impact on patient lives and staff workflow!**

Thanks!

AQPMC
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