LECTURER: Nghia Duong-Trung

ARTIFICIAL INTELLIGENCE

TOPIC OUTLINE

UNIT 2

MODERN AI SYSTEMS

STUDY GOALS

- Differentiate between narrow and general artificial intelligence.
- Identify the most important applications in AI.
- Describe AI in corporate activities.
- Evaluate AI systems.

EXPLAIN SIMPLY

1. What is the difference between narrow and general AI?

2. In which areas can AI be used?

3. How can AI systems be evaluated?

NARROW VS GENERAL AI

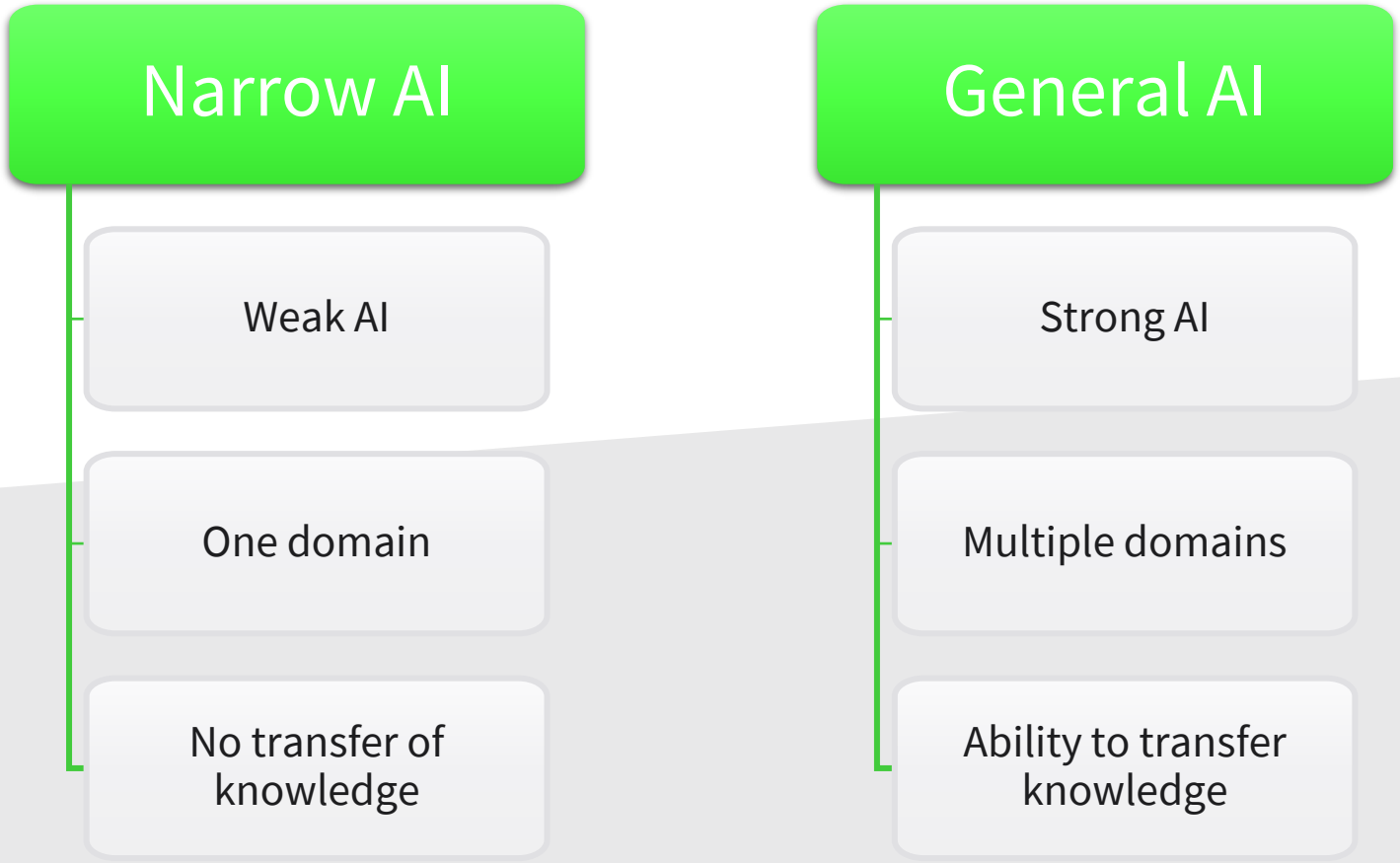


Image Source: Custom Depiction

APPLICATION AREAS OF AI

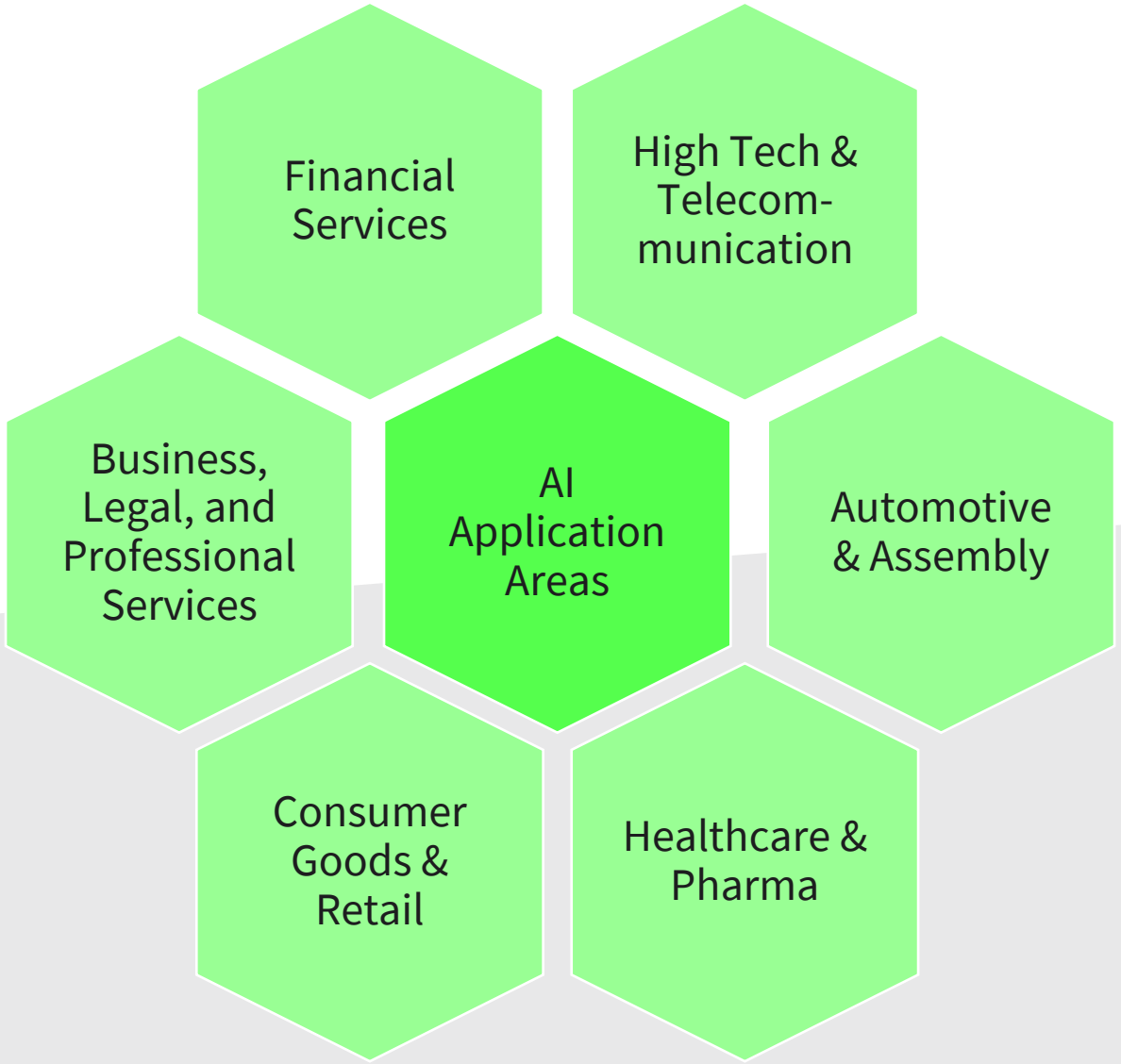
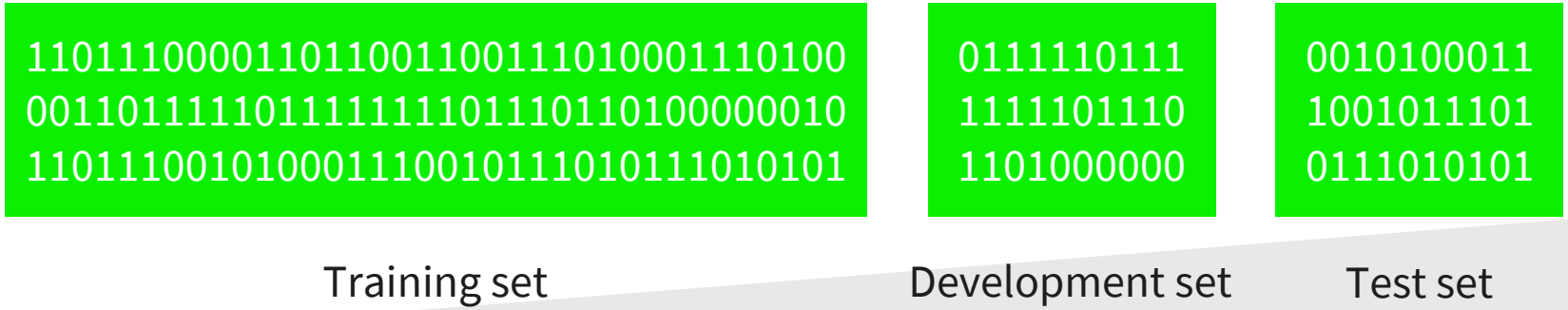


Image Source: Custom Depiction

EVALUATION OF AI SYSTEMS



Training set

Development set

Test set

Image Source: Custom Depiction

THE CONFUSION MATRIX

		Predicted result: True	Predicted result: False
Actual result	**True**	True positive	False negative
	False	False positive	True negative

Source of Table: Custom Depiction

EVALUATION METRICS

PRECISION

$$\frac{TP}{TP + FP}$$

RECALL

$$\frac{TP}{TP + FN}$$

EVALUATION METRICS

ACCURACY

$$\frac{TP + TN}{TP + TN + FP + FN}$$

F-SCORE

$$2 \cdot \frac{precision \cdot recall}{precision + recall}$$

REVIEW STUDY GOALS

- Differentiate between narrow and general artificial intelligence.
- Identify the most important applications in AI.
- Describe AI in corporate activities.
- Evaluate AI systems.

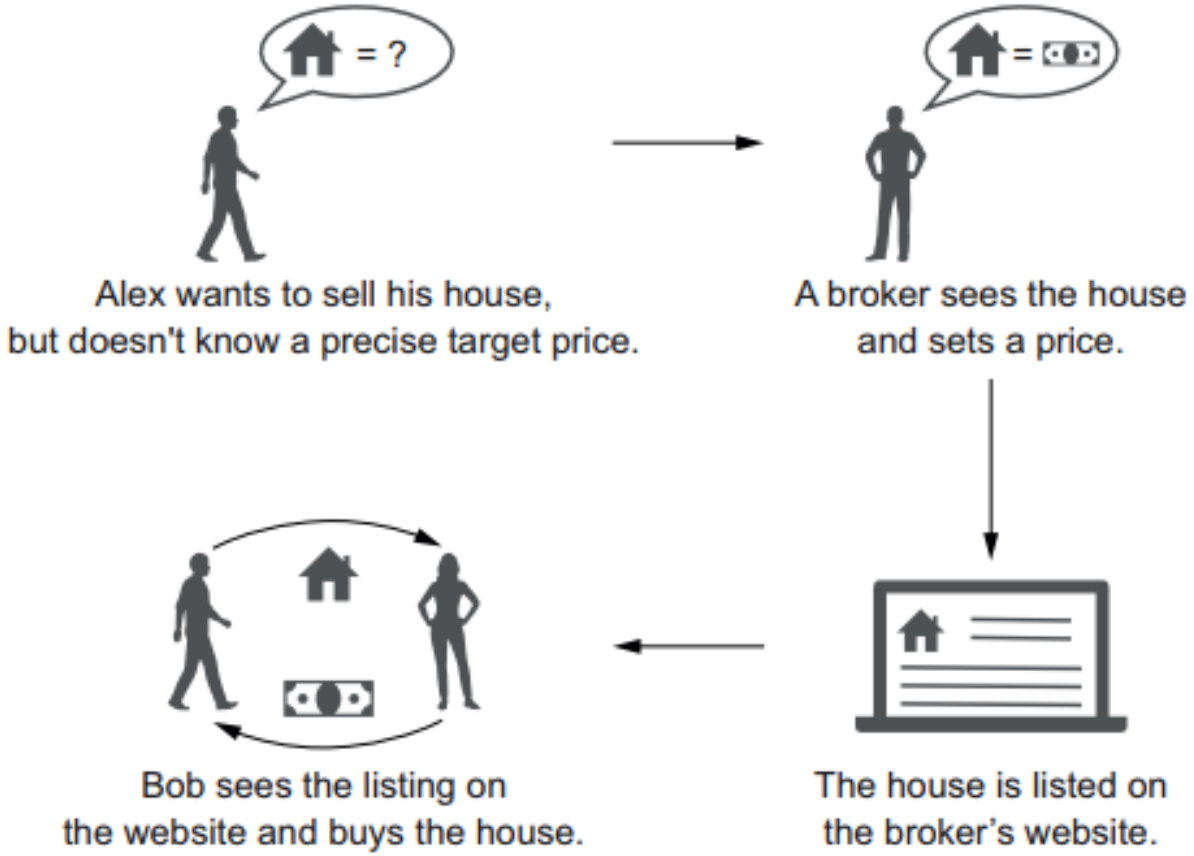
AI FOR CORE BUSINESS DATA

- “core business data”: direct impact on the organization
  - Cart history for an e-commerce operation
  - Physical measurements for an engineering organization
  - Patient behavior for a health-care company
- “dollar/euro density of data”: how much the data influences the top or bottom line of the organization
  - As you move away from the core value proposition of your organization, the dollar density of data decreases accordingly

- Let discuss about a simplified example: FutureHouse
  - a fictional business that operates an online real estate marketplace where homeowners can advertise their homes for sale and attract interested buyers
  - Prioritizes customer service and employs agents who can offer their support to help sellers assess their house price
  - Buyers use the site to look for the house of their dreams.

USING AI WITH CORE BUSINESS DATA

1. A customer comes in looking to sell their house. Before they put it on the market, they want a professional opinion about how much it's worth.
2. The broker checks out the house and sets a price based on its square footage, age, included appliances, neighborhood, near public transport, and so on.
3. The house gets listed.
4. Potential buyers find the listing and eventually gets to buy the property.



USING AI WITH CORE BUSINESS DATA

- What kind of data FutureHouse should collect?
  - Square footage
  - Number of bedrooms
  - Number of bathrooms
  - Number of floors
  - Year of construction
  - Does it have a garage?
  - Energy efficiency
  - Public transportation
  - Location
  - Quality of the neighborhood
- “by experience”
  - Might refer to standard guidelines like the average price per square foot, but it’s hard for them to articulate how other factors affects the price
  - If you can’t explain your making process, you can’t even code it into a computer program

ADDING AI CAPABILITIES TO FUTUREHOUSE

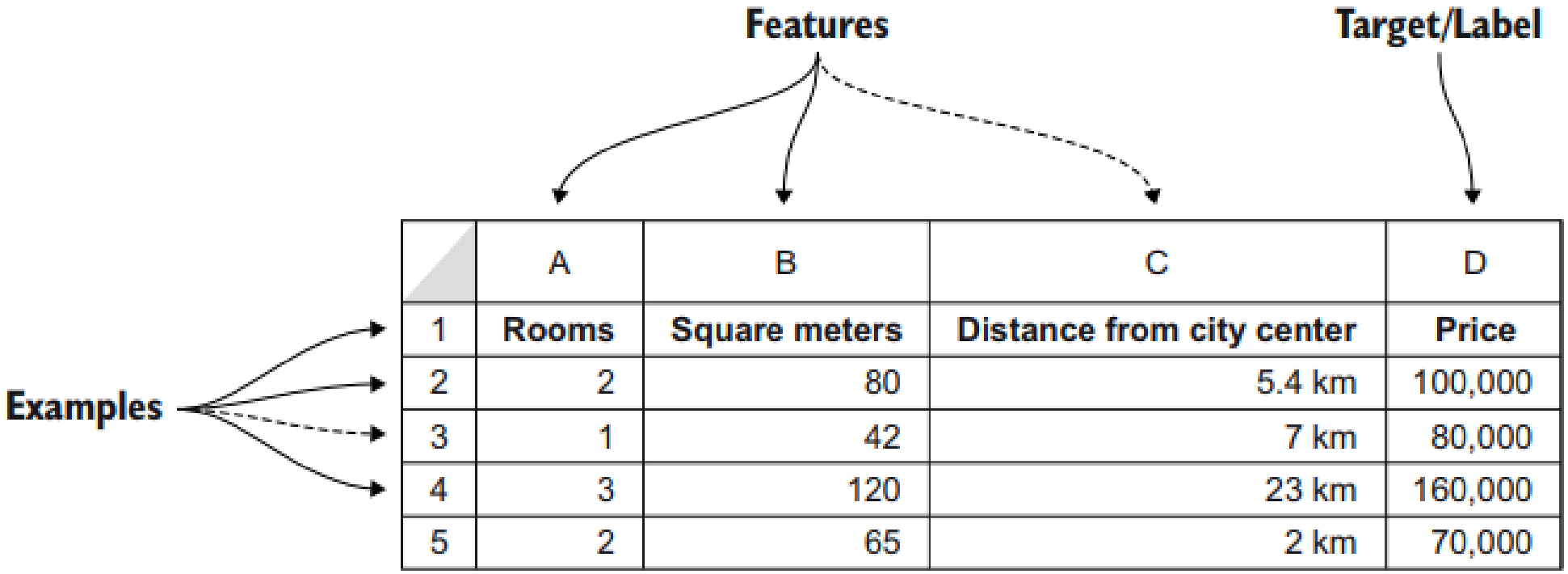
- We'd like to add an automatic price predictor to our real estate listings website

- We have a list of factor

- The expected property price
- We have records for all house transactions in the region for the past 10 years
- Most of them. Some missing data.
- Yes, the records include the final price of each property
- Around 200,000 transactions

- This is a standard problem in ML. There are some good **ML algorithms** that can produce a good **model**. What **inputs** do we have?
- The list of **features** is a good start. What **target** do you need from the model?
- Good. What data do you have available for this?
- Do those records include all the **features** you mentioned earlier?
- Do you also have **labels** for all of them?
- How many examples have you collected?

- That should be enough to **train the model**

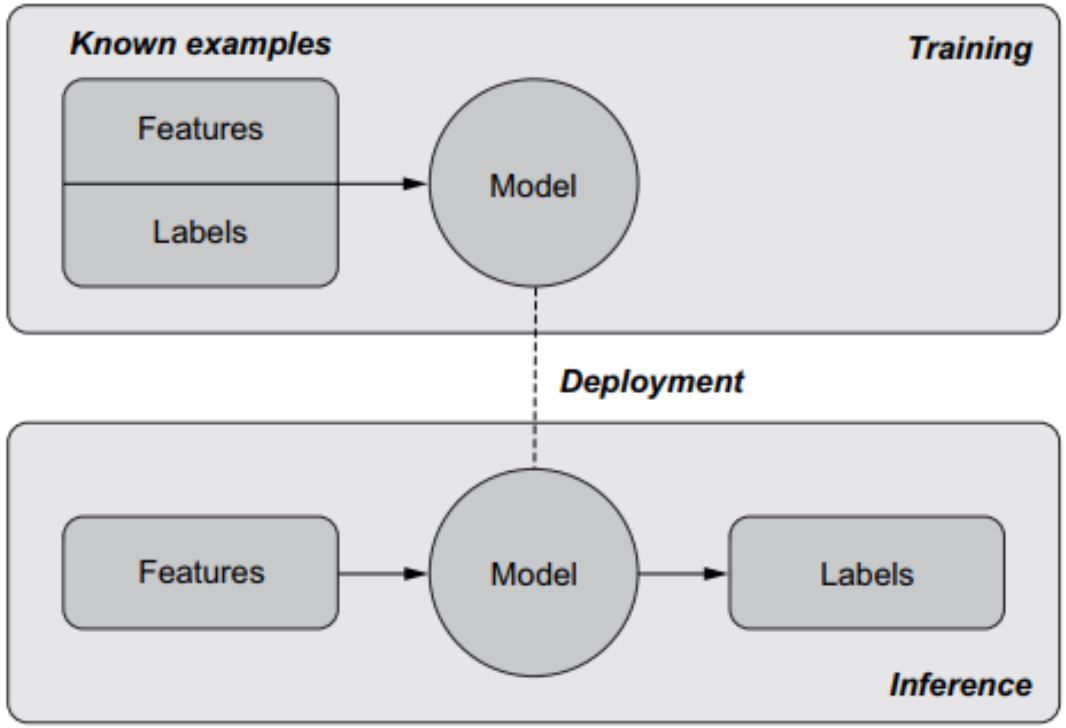


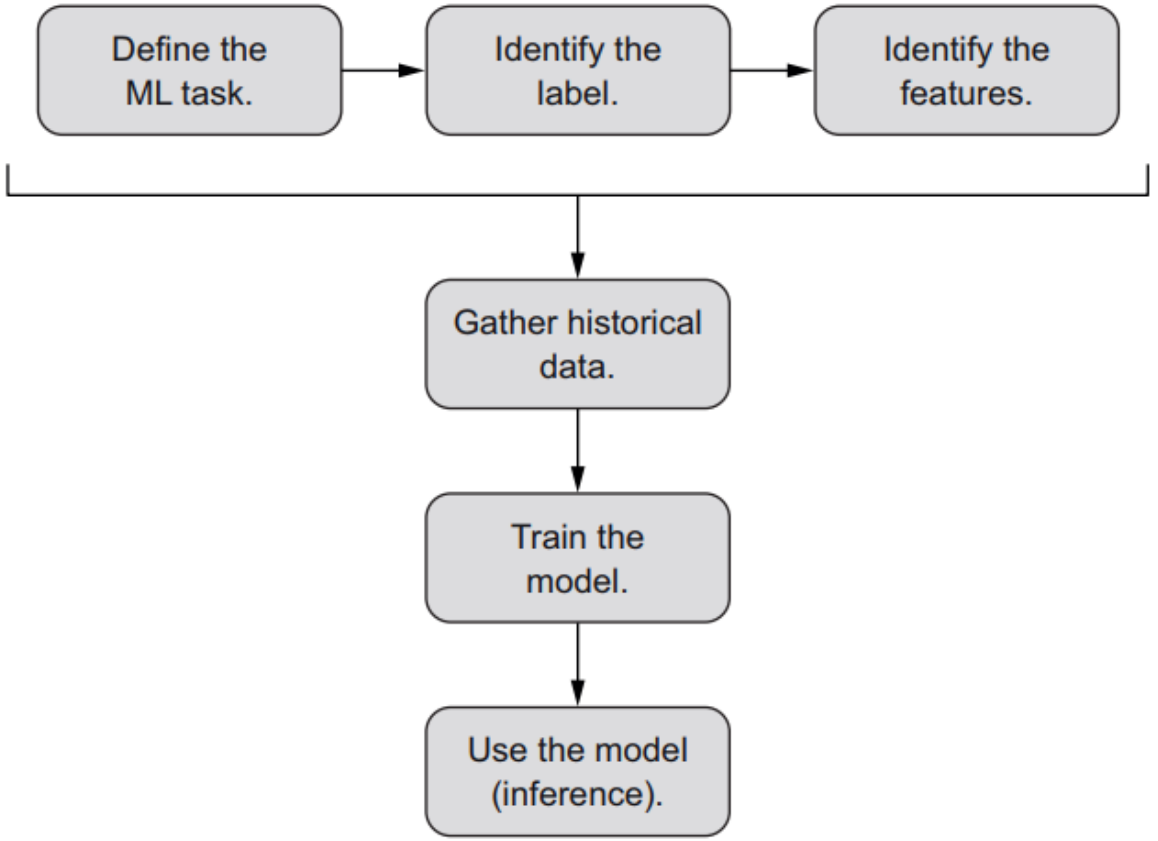
	A	B	C	D
1	**Rooms**	**Square meters**	**Distance from city center**	**Price**
2	2	80	5.4 km	100,000
3	1	42	7 km	80,000
4	3	120	23 km	160,000
5	2	65	2 km	70,000

ADDING AI CAPABILITIES TO FUTUREHOUSE

- Our ML engineer asks for historical data because they have to instruct the computer to go through a process called **training**.
- Just as an experienced broker can guess the price, a ML algorithm can learn how to predict the price based on past examples.
- The engineer writes code to feed the model with the thousands of examples; each example contains both the features and their corresponding label.
- Once training is complete, we have a self-contained computer program (the model) that packs all the predictive power of house-price prediction.
- Anytime we want to evaluate a new home, we can feed its features to the model and get an answer about its likely price on the market. This step is call **inference**.
- Once the model is trained, the engineer plugs it into FutureHouse's website and the model starts answering customer's requests as they come in.

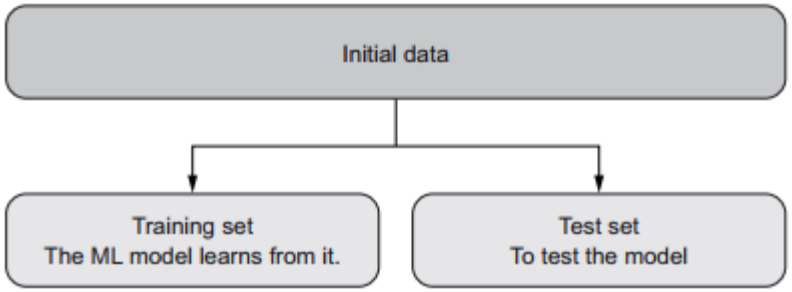
- More generally, all problems for which we want to predict a value based on a set of information: **supervised learning**.





EVALUATING PERFORMANCE AND RISK

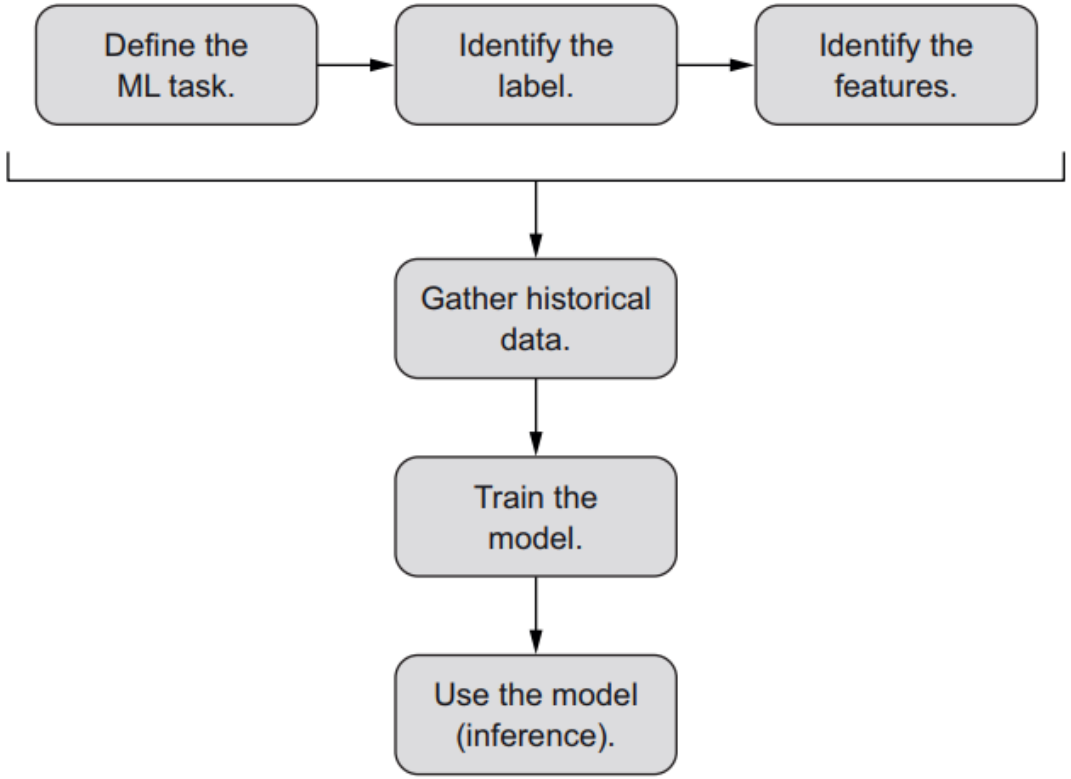
- ML is based on data and statistics, and thus its predictions will likely **never** be 100% accurate.
- But we do want predictions to be valuable to the business, while respecting all standards of safety and ethics.
  - Companies using ML in life-or-death situations must be much more careful and conservative than marketers using it to optimize their messaging to customers
- Evaluating the performance of a model has two main aspects: **known unknowns** and **unknown unknowns**.
- The main known unknown is accuracy
  - Randomly split the initial data into a training set and a test set. Because the test set was also from the initial dataset, we do have labels



EVALUATING PERFORMANCE AND RISK

- “All models are wrong, but some are useful” – statistician George Box.
- An inaccurate model applied to the right problem can be way more valuable to the business than a very accurate model that solves an insignificant problem.
- Unknown unknowns
  - The model gives a flat-out incorrect or nonsensical answer
  - More often than not, this is because the training data was incomplete, and we’re trying to predict the target in a situation (a combination of features) that was never seen before in training
  - Wholly unpredictable queries can still throw off the model
  - Need constrains from experts
- ML can tackle many hard problems where conventional software engineering fails, because it’s based on historical data rather than mathematical understanding.

- Predict churning customers
  - The churn is defined as the percentage of customers leaving a business over a period of time.
  - Wouldn’t it be amazing to know beforehand which customers are unhappiest and most likely to abandon a product or service in the near future
  - Binary classification



- Do you know what is affecting the customer churn? I need to come up with some relevant features.

- I'll use a feature in the model that expresses "contract" or "prepaid". Another feature will be the number of days to the expiration of the contract. Anything else?
- We can look in the customer relationship management system (CRM) and include a feature for "days since sign-up" and one for age.
- …

- Sure, we know that the payment setup is highly relevant to churn. Usually, someone who has a contract instead of a prepaid card is less likely to abandon the service. It's also true that when we're close to the expiration date of a contract, customers start looking at competitors.
- Age plays a big role. Young millennials change companies all the time, while older people are more loyal. A long-time client is a good indicator of loyalty.
- The occupation is important. We know that the self-employed are less eager to change plans.

- …

AI FOR SALES AND MARKETING: EVALUATION

		Predicted (What the algorithm has predicted)	
Actual (What the data says)		True positives (Customers identified by the algorithm as churned, and it was right)	False negatives (Customers identified by the algorithm as not churned, but it was wrong)
		False positives (Customers identified by the algorithm as churned, but it was wrong)	True negatives (Customers identified by the algorithm as not churned, and it was right)

CLASSIFICATION MODEL EVALUATION METRICS

- **Accuracy** → Fraction of correct predictions (TP+TN) of all predictions
- **Precision** → Cost of False Positive (FP) is high (*Spam Detection*)
- **Recall** → Cost of False Negative (FN) is high (*Cancer Detection*)

$$\text{Accuracy} = \frac{\Sigma TP+TN}{\Sigma\ TP+FP+TN+FN}$$

$$\text{Recall} = \frac{\Sigma TP}{\Sigma\ TP+FN}$$

$$\text{Precision} = \frac{\Sigma TP}{\Sigma\ TP+FP}$$

Confusion Matrix

		Actual Class	
		YES	NO
Predicted Class	YES	TP	FP
	NO	FN	TN

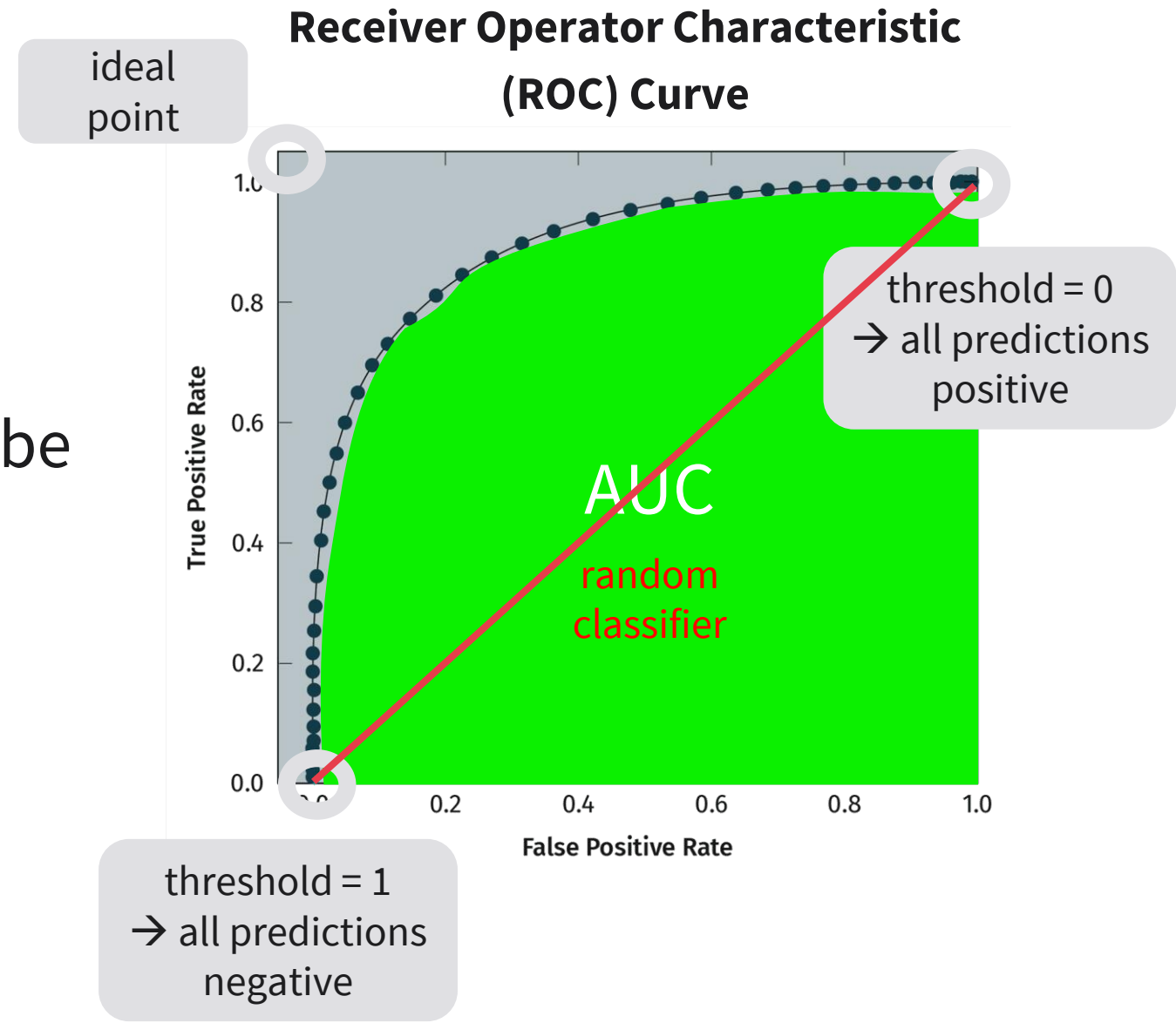
Source of the graphic: IU International University, Course Book DLMBDSA01.

- https://deepai.org/machine-learning-glossary-and-terms/f-score#:~:text=The%20F%2Dscore%2C%20also%20called,positive'%20or%20'negative'.
- The F-score is a way of combining the precision and recall of the model, and it is defined as the harmonic mean of the model's precision and recall.

$$F_1 = \frac{2}{\frac{1}{\text{recall}} \times \frac{1}{\text{precision}}} = 2 \times \frac{\text{precision} \times \text{recall}}{\text{precision} + \text{recall}}$$
$$= \frac{\text{tp}}{\text{tp} + \frac{1}{2}(\text{fp} + \text{fn})}$$

CLASSIFICATION MODEL EVALUATION METRICS

- classification models output probabilities
- ROC = visualization of model performance with different thresholds for a probability to be positive/negative prediction
- best model performance:
  - curve close to upper left corner
  - higher Area under the Curve (AUC)



Source of the graphic: IU International University, Course Book DLMBDSA01.

REGRESSION MODEL EVALUATION METRICS

$$\text{MAE} = \frac{\sum|\hat{Y} - Y|}{n}$$

→ ***robust to outliers***

$$\text{MSE} = \frac{\sum(\hat{Y} - Y)^2}{n}$$

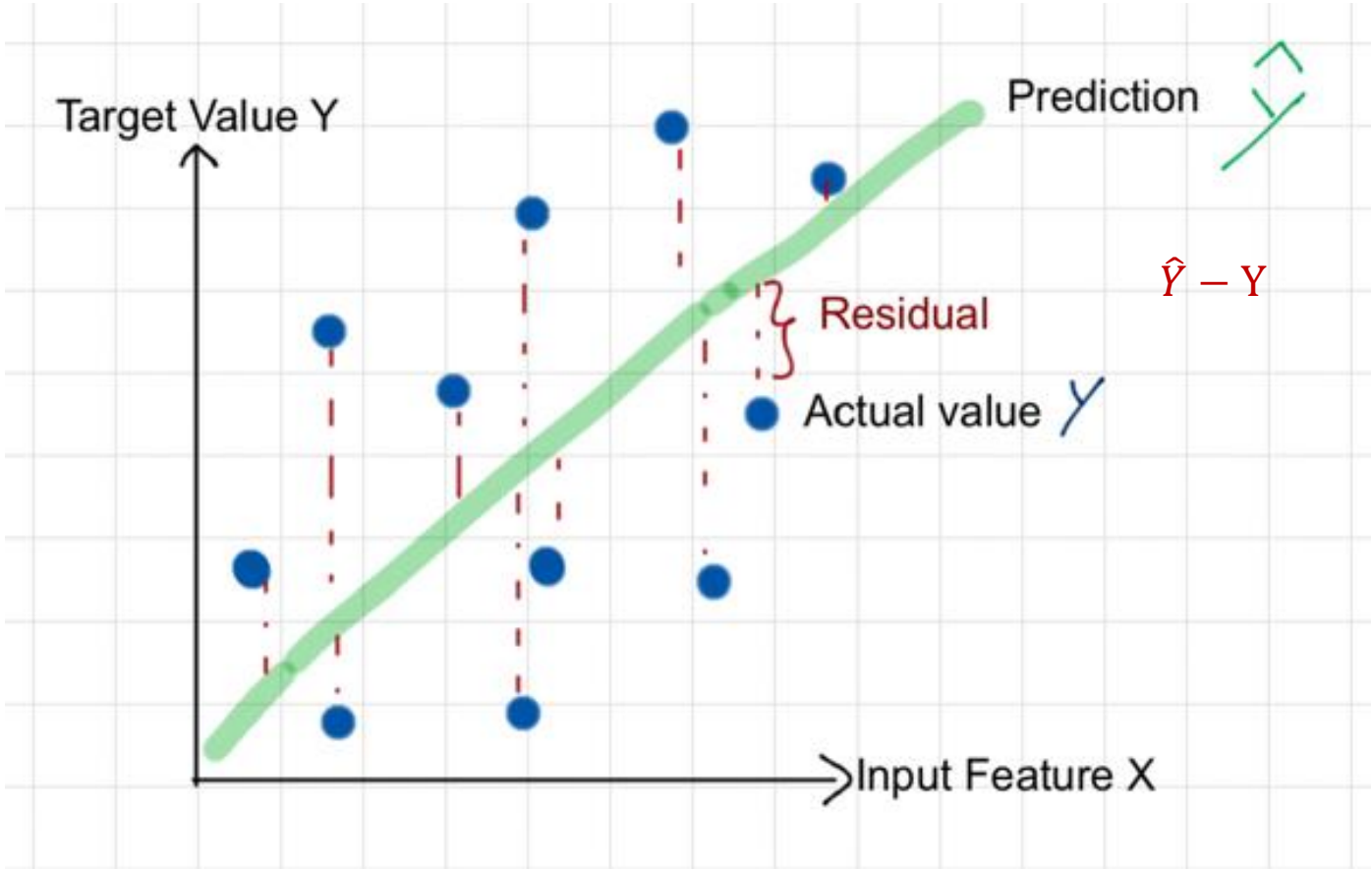
→ ***weights larger errors higher***

$$\text{RMSE} = \sqrt{MSE}$$

→ ***advantage to MSE: original unit***

$$\text{MAPE} = \frac{1}{n}\sum\left|\frac{\hat{Y} - Y}{\hat{Y}}\right|$$

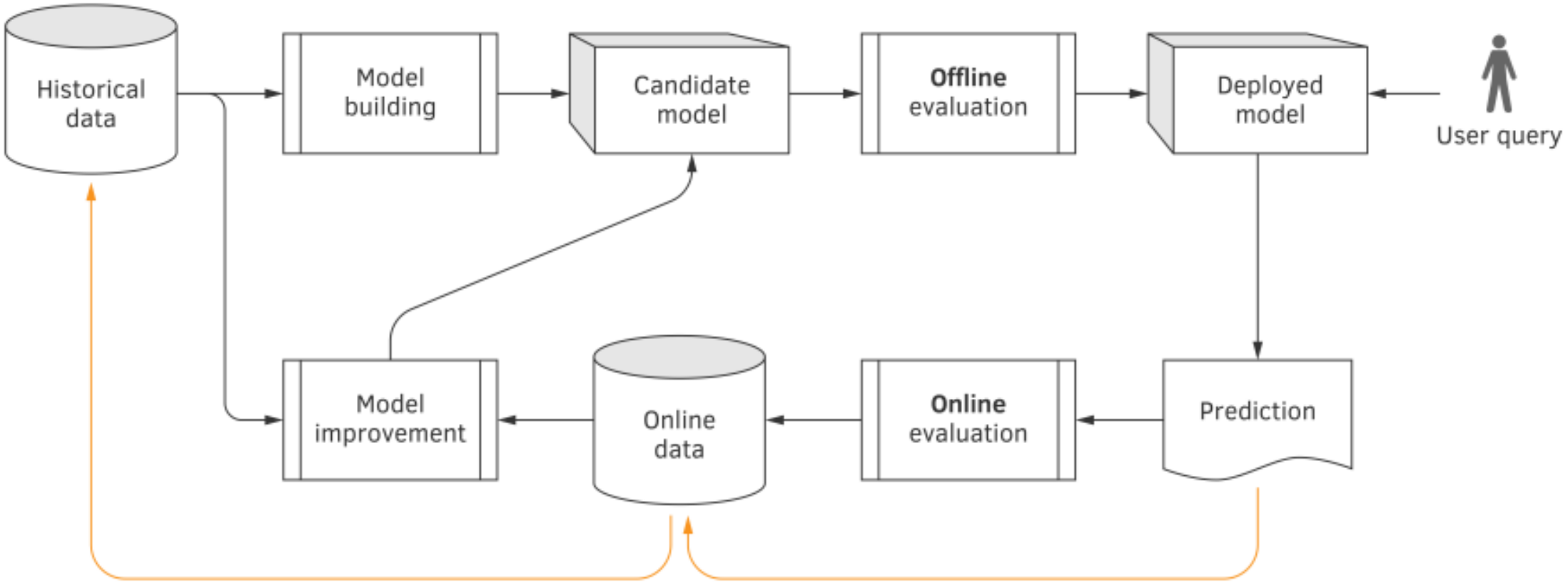
→ ***mean of absolute percent differences***



Source of the graphic: Drawing by Antonia Schulze, 2021.

OFFLINE AND ONLINE EVALUATION

- An offline model evaluation happens when the model is being trained by the analyst
- The online evaluation happens when the model is being tested in production by using online data



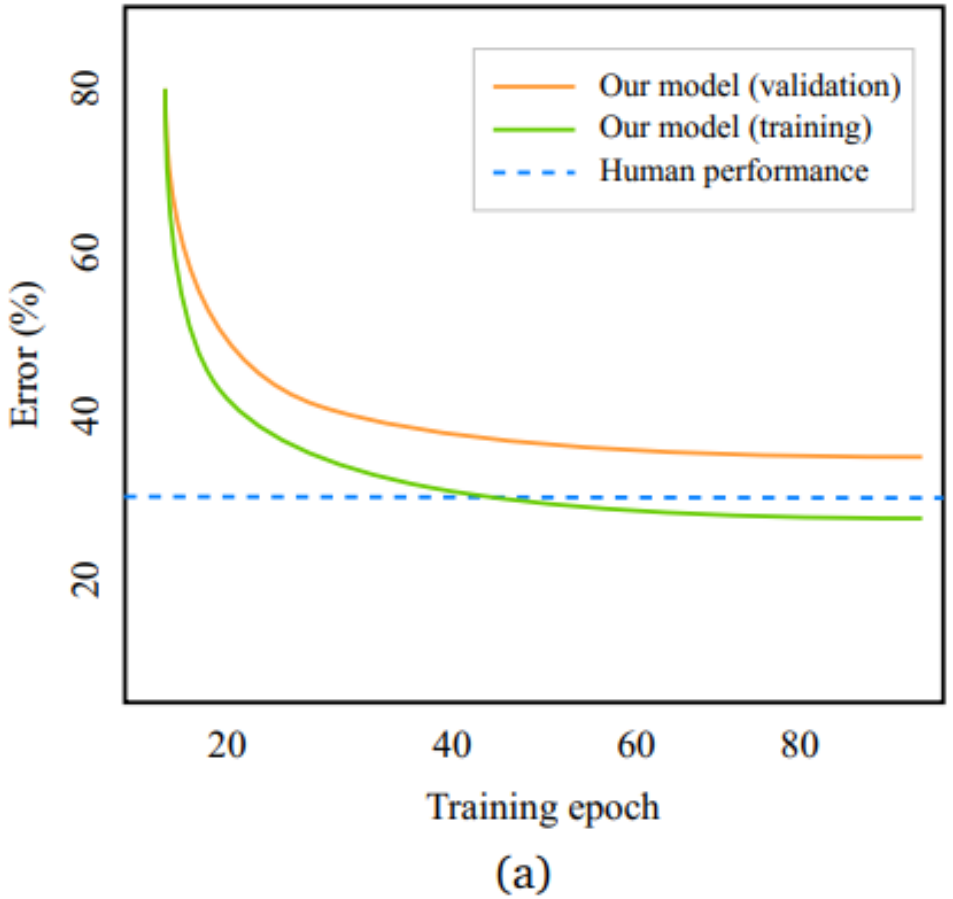
BEFORE THE PROJECT STARTS

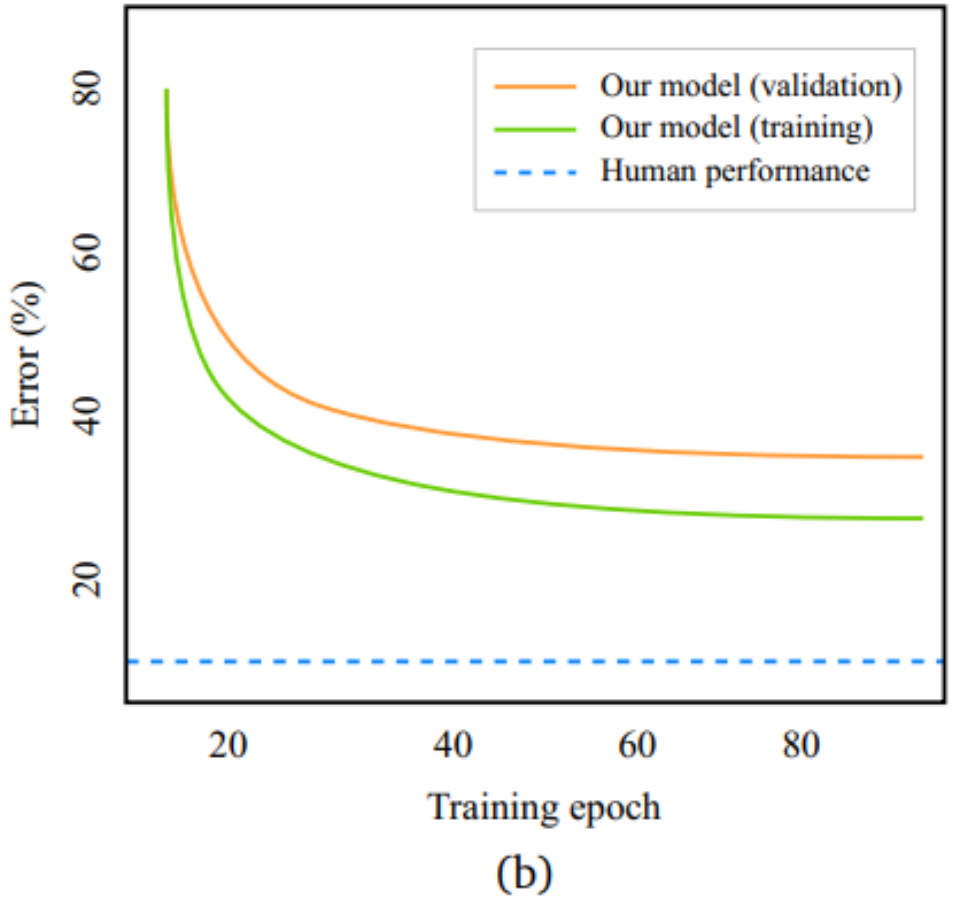
- Goal of ML
  - A model that solves, or helps solve, a business problem. Within a project, the model is often seen as a black box described by inputs, outputs and acceptable level of performance
- Impact of ML
  - ML can replace a complex part in your engineering project or
  - There’s a great benefit in getting inexpensive (but probably imperfect) predictions
- Cost of ML
  - The problem difficulty
  - The cost of data, and
  - The need for accuracy
- Simplify the problem
  - Start small for debug, then deploy it bigger

BEFORE THE PROJECT STARTS

- Properties of a successful model
  - It respects the input and output specifications and the performance requirement
  - It benefits the organization (measured via cost reduction, increased sales or profit)
  - It helps the user (measured via productivity, engagement, and sentiment)
  - It is scientifically rigorous
- Team of ML
  - ML skill, software development skill, data engineering skill, data labeling skill, research skill, DevOps
- Why ML projects fail
  - Lack of experienced talent
  - Lack of clearly defined expected deliverables
  - Data infrastructure and labeling challenge
  - Lack of collaboration and alignment
  - Technically infeasible projects

MODEL PERFORMANCE VS HUMAN BASELINE





ONLINE COURSES

https://www.udemy.com/course/deep-learning-machine-learning-practical/

Machine Learning Practical Workout | 8 Real-World Projects

- Project 1: ANN – car sales prediction
- Project 2: Deep NN – CIFAR10 classification
- Project 3: Prophet time series – Chicago crime rate
- Project 4: Prophet time series – Avocado market
- Project 5: LE-NET Deep Network – Traffic sign classification
- Project 6: NLP – Email spam filter
- Project 7: NLP – YELP reviews
- Project 8: User-based collaborative filtering – Movie recommender system

DATA SCIENCE USE CASES (DSUCS)

https://data-flair.training/blogs/data-science-use-cases/

- Data sources
- Type of ML

ONLINE COURSES

https://www.superdatascience.com/courses/data-science-for-business-case-studies

Data Science for Business | 6 Real-world Case Studies

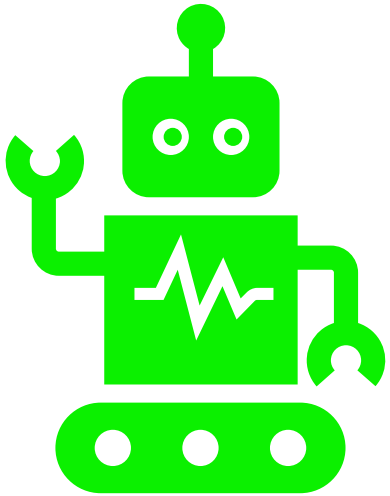
1. **Task #1 @Human Resources Department:** Develop an AI model to Reduce hiring and training costs of employees by predicting which employees might leave the company.
2. **Task #2 @Marketing Department:** Optimize marketing strategy by performing customer segmentation
3. **Task #3 @Sales Department:** Develop time series forecasting models to predict future product prices.
4. **Task #4 @Operations Department:** Develop Deep Learning model to automate and optimize the disease detection processes at a hospital.
5. **Task #5 @Public Relations Department:** Develop Natural Language Processing Models to analyze customer reviews on social media and identify customers sentiment.
6. **Task #6 @Production/Maintenance Departments:** Develop defect detection, classification and localization models.

SESSION 2

TRANSFER TASK

TRANSFER TASK

1. Describe at least five characteristics that a humanoid robot equipped with an AGI would have to possess.



2. Reflect on how AI could contribute to reducing the workload of the HR department of a company.

3. Imagine you want to compare two computer vision algorithms for the detection of cancer. From the evaluation you get the following confusion matrices:

Algorithm 1		Predicted result	
		Cancer	No cancer
Actual result	Cancer	25	20
	No cancer	10	65

Algorithm 2		Predicted result	
		Cancer	No cancer
Actual result	Cancer	25	10
	No cancer	20	65

Compute precision, recall, accuracy, and F-score.

Which of the two algorithms would you choose and why?

TRANSFER TASK
PRESENTATION OF THE RESULTS

Please present your results.

The results will be discussed in plenary.

LEARNING CONTROL QUESTIONS

1. What sort of AI do current AI systems integrate?

2. What are the typical areas of application of AI?

3. Which data sets are required to develop AI systems?

DISCLAIMER

- This is the modified version of the IU slides.
- I used it for my lectures at IU only.