DEEP LEARNING:
CHALLENGES AND OPPORTUNITIES IN THE FOURTH INDUSTRIAL AGE

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OUTLINE

- Intro to Machine Learning
- Deep Learning
- Economic Impacts of AI
- Pulp & Paper Industry 4.0

INTRODUCTION TO MACHINE LEARNING

ML : AN APPROACH TO AI

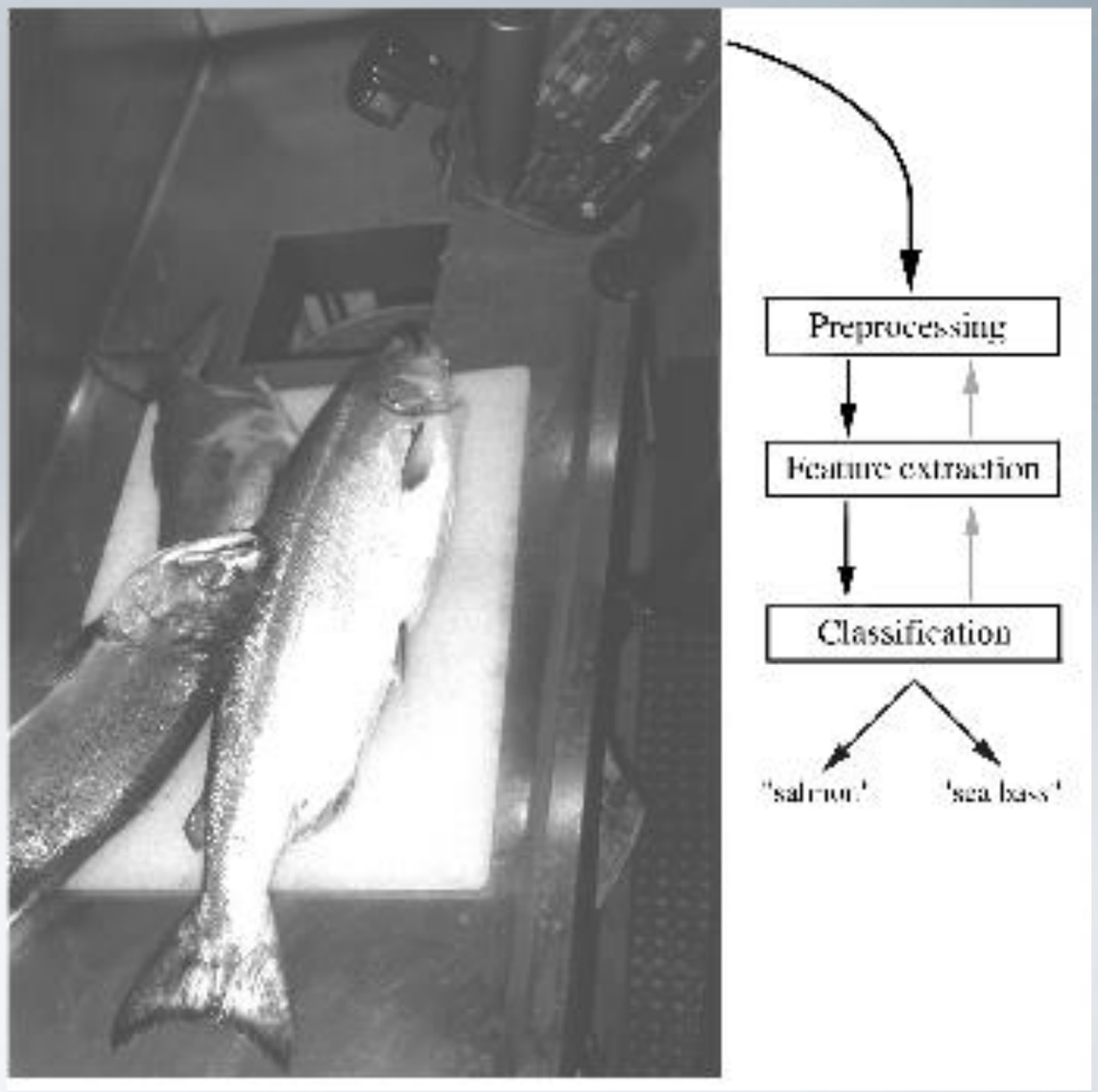
- QUESTION: How can we program computers to do/know things humans do/know, when we do not even know how we ourselves do/know these things? Eg. recognizing patterns, walking, speaking a language, etc.

- HINT: We do not know how we do/know but we know that we learned how to do/know these things!

- SOLUTION: Programming computers to learn how to do/know things by themselves by looking at examples from the real world.

PATTERN RECOGNITION

- Model choice (MLP, SVM, DBN, ...)
- Pre-processing / segmentation
- Feature extraction ("help the model" with *a priori* knowledge vs losing information)
- Training samples
- Cost function (MSE, max likelihood, reward function, ...)
- Training algorithm (gradient descent, EM, ...)



CLASSIFICATION

Length

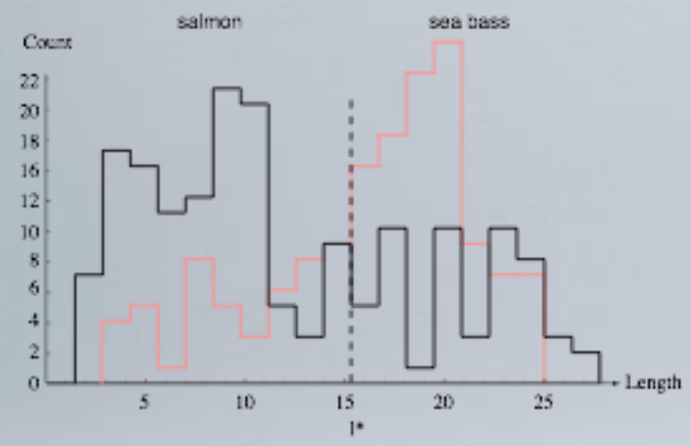


Figure 1.2: Histograms for the length feature for the two categories. No single threshold value l^* (decision boundary) will serve to unambiguously discriminate between the two categories; using length alone, we will have some errors. The value l^* marked will lead to the smallest number of errors, on average.

Lightness

Figure 1.3: Histograms for the lightness feature for the two categories. No single threshold value x^* (decision boundary) will serve to unambiguously discriminate between the two categories; using lightness alone, we will have some errors. The value x^* marked will lead to the smallest number of errors, on average.

Source: Duda, R. O., Hart, P. E. and Stork, D. G. (2000) *Pattern Classification* (2nd edition). Wiley-Interscience, 654 pages.

GENERALIZATION

Linear classifier

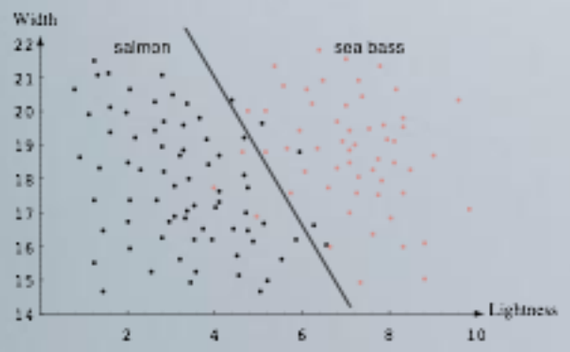


Figure 1.4: The two features of lightness and width for sea bass and salmon. The dark line might serve as a decision boundary of our classifier. Overall classification error on the data shown is lower than if we use only one feature as in Fig. 1.3, but there will still be some errors.

Overfitting

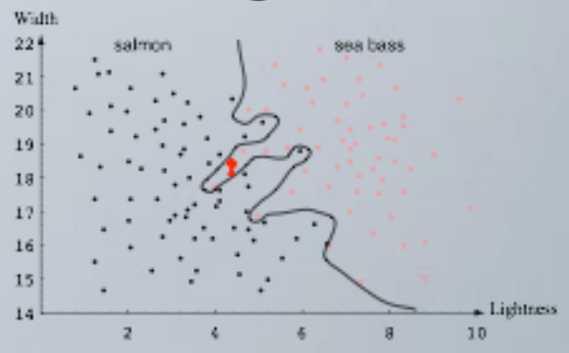


Figure 1.5: Overly complex models for the fish will lead to decision boundaries that are complicated. While such a decision may lead to perfect classification of our training samples, it would lead to poor performance on future patterns. The novel test point marked ? is evidently most likely a salmon, whereas the complex decision boundary shown leads it to be misclassified as a sea bass.

Optimal

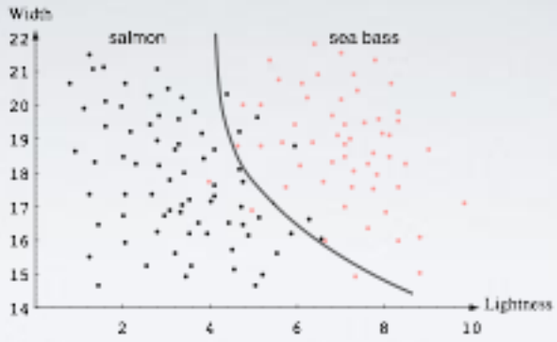


Figure 1.6: The decision boundary shown might represent the optimal tradeoff between performance on the training set and simplicity of classifier.

Source: Duda, R. O., Hart, P. E. and Stork, D. G. (2000) *Pattern Classification* (2nd edition). Wiley-Interscience, 654 pages.

THREE FORMS OF LEARNING

- Supervised (tagged data, perceptron, MLP)
- Unsupervised (hard and soft clustering, dimensionality reduction, auto-encoders)
- Reinforcement (agent, TD-lambda, reward function)

DEEP LEARNING

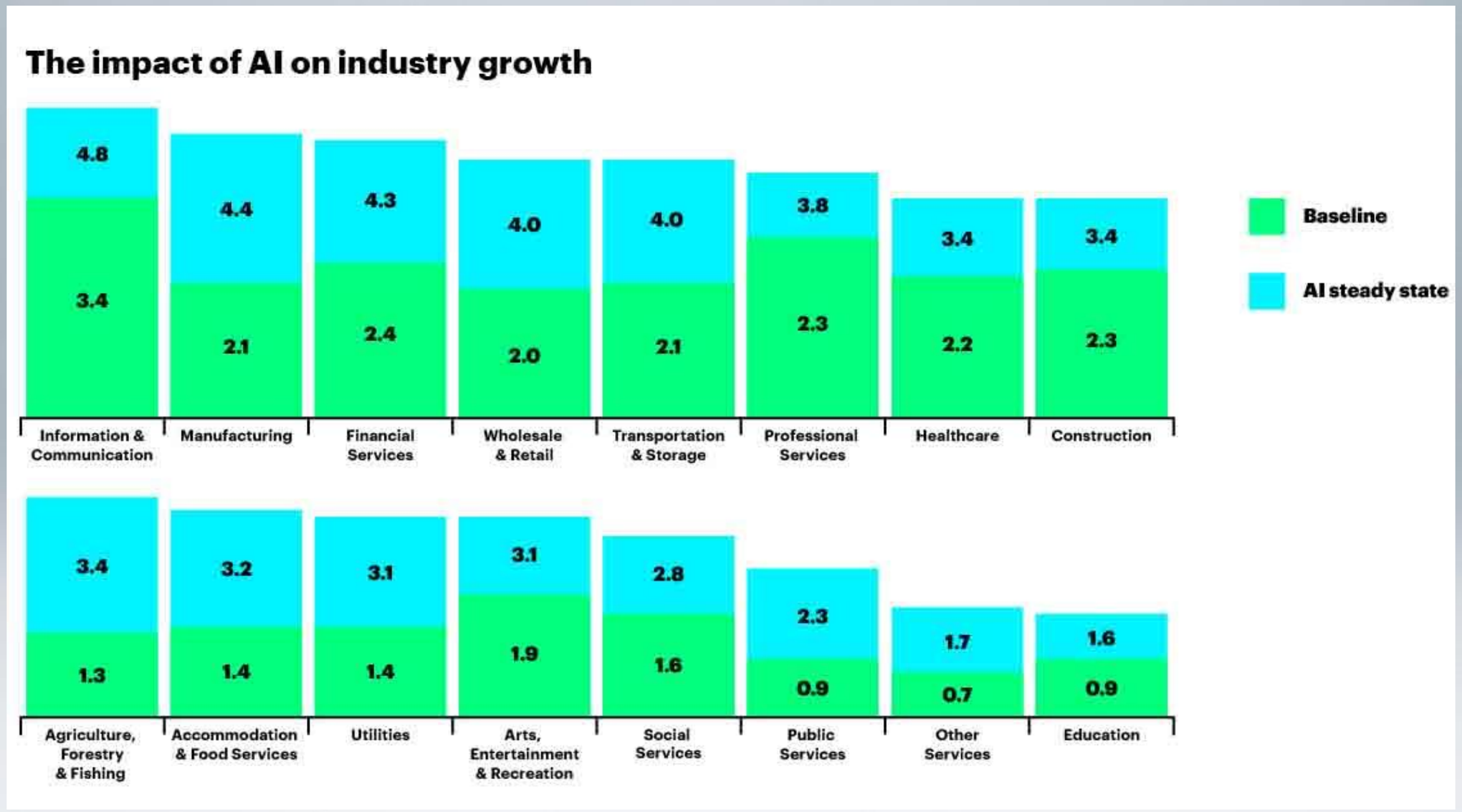
- Approach to machine learning
- Uses hierarchies of interconnected layers of simple units (neurons)
- Impressive results since mid-2000s allowed for a “quantum leap” in the field
- Generalizable to many different applications (image, sound, language, stock markets, industries, etc)

ECONOMIC IMPACTS OF AI

- Profitability increase of 38% by 2035 for businesses that successfully apply AI
- AI could lead to an economic boost of $14 trillion in additional gross value added (GVA) across 16 industries in 12 economies
- Manufacturing is the second sector where AI will likely have the most impact on profits

Source: Purdy, M. & Daugherty, P. Why Artificial Intelligence is the Future of Growth. Accenture, 2017.

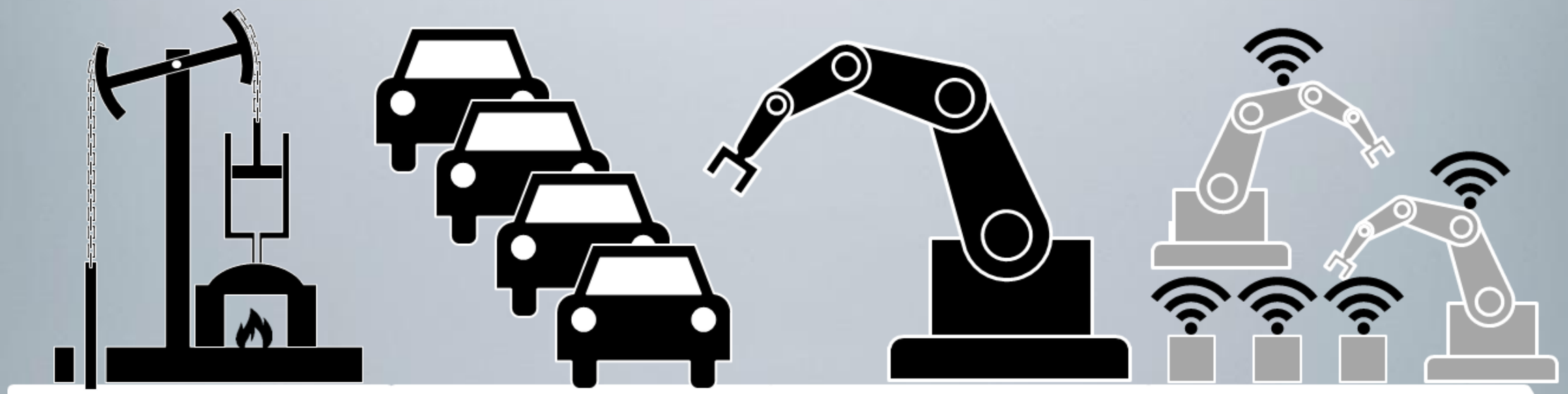
ECONOMIC IMPACTS OF AI



Annual growth rates by 2035 of gross value added (a close approximation of GDP), comparing baseline growth to an artificial intelligence scenario where AI has been absorbed into a sector's economic processes

Source: Accenture Report: Artificial Intelligence Has Potential to Increase Corporate Profitability in 16 Industries by an Average of 38 Percent by 2035.

INDUSTRY 4.0



1st	2nd	3rd	4th
Mechanization, water power, steam power	Mass production, assembly line, electricity	Computer and automation	Cyber Physical Systems

INDUSTRY 4.0

- Interoperability
- Information transparency
- Technical assistance
- Decentralized decision-making

DEEP LEARNING APPLICATION FOR SMART PULP & PAPER FACTORY

- Process Monitoring
- Anomaly Detection
- Root Cause Analysis
- Manufacturing Processes Optimization
- Digital Twins

DEEP LEARNING FOR PULP & PAPER BEYOND THE FACTORY

- Marketing & advertising
- Business Relationships
- Transportation Optimization

THANK YOU!