introduction

- deep learning is all about lots of experience (training data) and understanding the world in terms of a hierarchy of concepts and acknowledging that there are lots of concepts (some related, some not), the idea of distributed representations.
- lots of AI efforts have been made to hardcode knowledge → the knowledge base approach. but this hasn't worked well.
- a lot of ML before deep learning focused on hand designed and extracted features. for more complicated tasks, it is difficult to know what features matter and how they matter. so deep learning says "don't hand design the features, just learn them".
- the whole goal is to learn "factors of variation" → things about the input that matter for different things. deep learning recognizes that different things matter for different tasks/goals and provides lots of capacity for distributed learning of these features of variation. here, "distributed" refers to the fact that there are a bunch of nodes, each trying to learn something different and deeper and deeper layers that learn more abstract concepts and each feature (inner node) should be involved the representation of many possible inputs.
- the other main characteristic is that depth enables learning a multistep program like a sequential instruction program where later instructions can compute more complex things by referring back to earlier instructions.
- representational power + ability to learn/train that representation is what matters. great representation power with poor training works worse than decent representation with great training.
- the main advantage of distributed representation is being able to learn about different aspects of things independently (the color vs shape vs associations between objects etc) without needing a combinatorial explosion of training data → this leads to much better statistical efficiency in terms of how much data is needed to learn.
- the basic approach:
  - rule-based systems (regular programs): hand-designed program
  - classic ML: hand designed features, learnt weights/learnt mapping from features to output.
  - deep learning: input → features → more abstract features → learnt mapping/weights → output. Notice the input → features and lack of hand designed features in deep learning.
- **History:**
  - previously known as cybernetics and connectionism. also called MLP (multi layer perceptrons)
  - neuroscience is kinda helpful today for DL but not super helpful. if we knew more about it, we could draw a lot more inspiration/theory/tricks.
  - neuroscience does give us reason to hope that a single deep learning algorithm can solve a big variety of tasks.
  - convolutional neural nets are the ones that have been most inspired by our knowledge of the visual system more than any other widely used model class.
  - while neuroscience has inspired models/architectures, it has not inspired so much teh methods of training used for these models.
  - backprop's successful use dates back to 1987
  - CNNs (used for images) were introduced in 1998, LSTMs (used for sequence modeling) in 1998.

    - the third wave of neural net research began in 2006 when geoff hinton showed that a neural net called deep belief network can be trained using a strategy called greedy layer-wise pretraining.
    - this wave of neural networks research popularized the use of the term “deep learning”.
- **some key enablers:**
    - increasing dataset sizes, driven by increasing digitization of society. a rough rule of thumb is that we need around 5k labeled examples per category and we will match/exceed human performance with at least 10 mil examples.
    - increasing model sizes because we have enough compute to train ‘em. better dataset sizes + increased model capacity has turned out to be quite powerful → the algorithm itself is not so important if you can throw at it lots of data. better CPUs, GPUs, software infrastructure, etc has helped here.
    - its tremendous impact on important and commercially valuable problems (image recognition, speech recognition, language translation etc) is driving more investment, resources, experts trained which is making things better.