Teaching Machines - Deep Learning and Education

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Preface

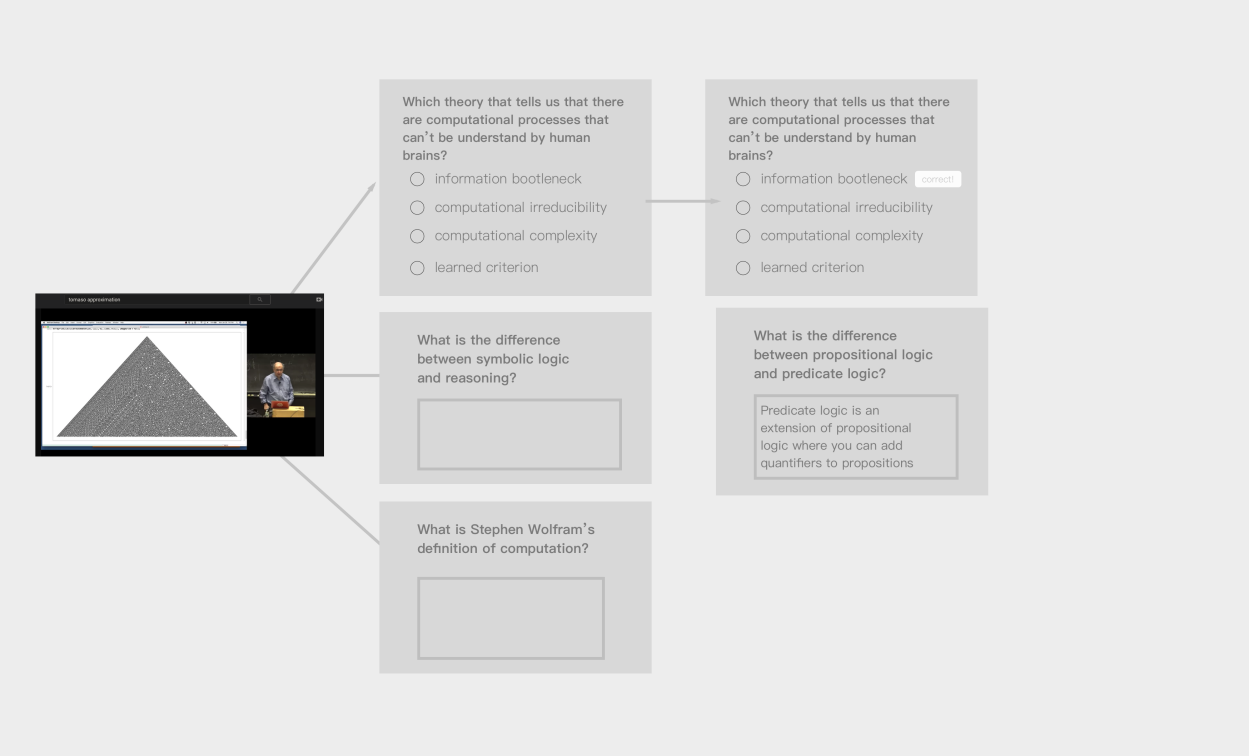


Figure 1: Our new paper on

Chapter 1

Introduction

Let's start with a future view of an individual's education. Many of us have used the internet to educate ourselves with the abundance of medium to high quality videos, papers, articles, podcasts and how-tos being uploaded from numerous individuals, groups, and institutions like never before (60 hours of video are uploaded to youtube.com every minute).

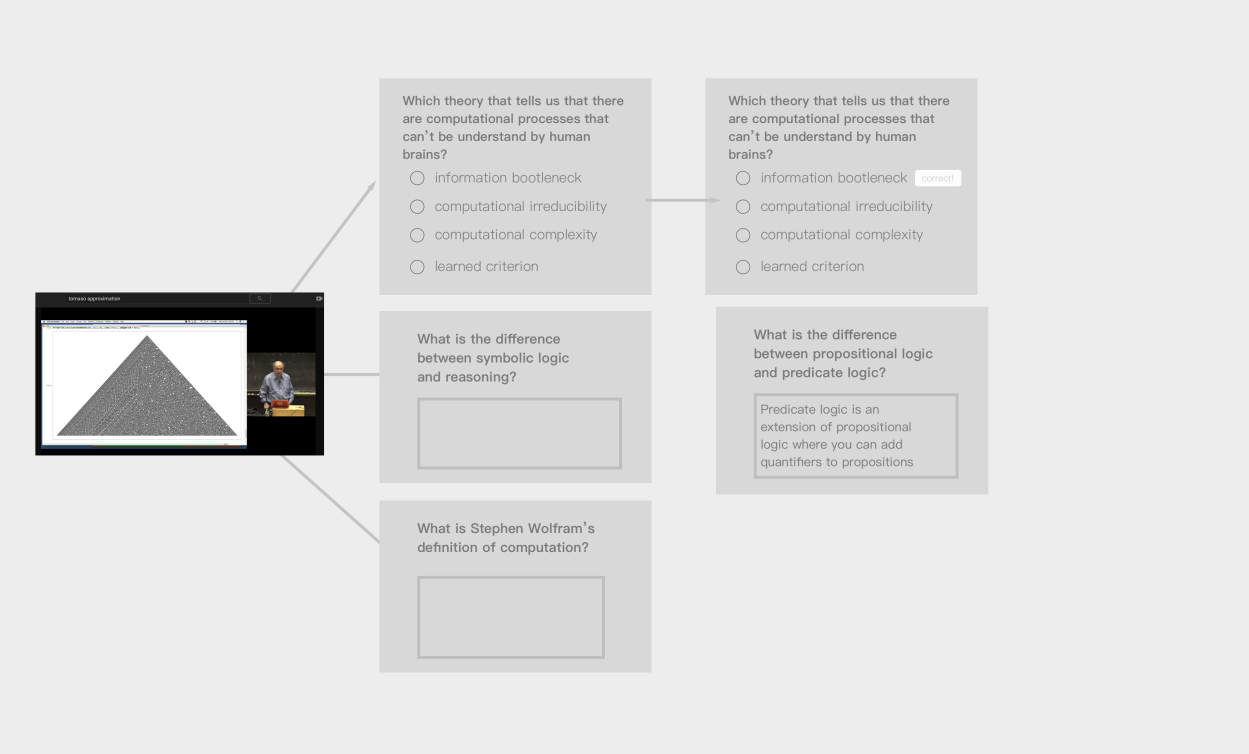
Let us imagine that all of what you have learned online, throughout the entirety of your life, from the hundreds of Youtube videos, Wikipedia articles, Nature papers, and podcasts you've read, watched, or listened to, were all added structurally to your very own **knowledge journey**, and what if that journey could be consolidated into what we might call a **knowledge footprint** that could be shared with others? Could this replace static degrees?

*For the purpose of this article we will talk mostly about digital knowledge acquisition and leave the reader to extend the basics to knowledge obtained elsewhere.

Our current approach to education is to treat education like a phase and if it only happens in one place. Watching a whole series of Youtube lectures on the Neurobiology of Depression or Discrete Mathematics goes mostly unnoticed when someone likes at one's resume or degree.

The ideas behind this knowledge ecosystem, present only one of many possible answers to bringing our education system into modernity. The goal would be to promote the long held idea of the life-long learner. Moving away from getting an education and recognition for a degree, to learning and being continously recognised for seeking to better understand the world for whatever the reason.

The goal of the **knowledge fingerprint** would be to showcase the broad range of a learner's knowledge (from making digital music to linear algebra) as well as the places they've went deeper than most (deep learning or philosophy of mathematics). This footprint, would be stable but always evolving, allowing an learner to update their knowledge while still being comprable to others. So instead of approaching education as a monolithic phase of our lives, this footprint would promote education as a life-long journey. It would also (combined with traditional education) begin to show us a more accurate depiction of an learner's and theorefore society's collective knowledge. With every new year, their footprint would evolve and extend just as the very thread of their lives would.



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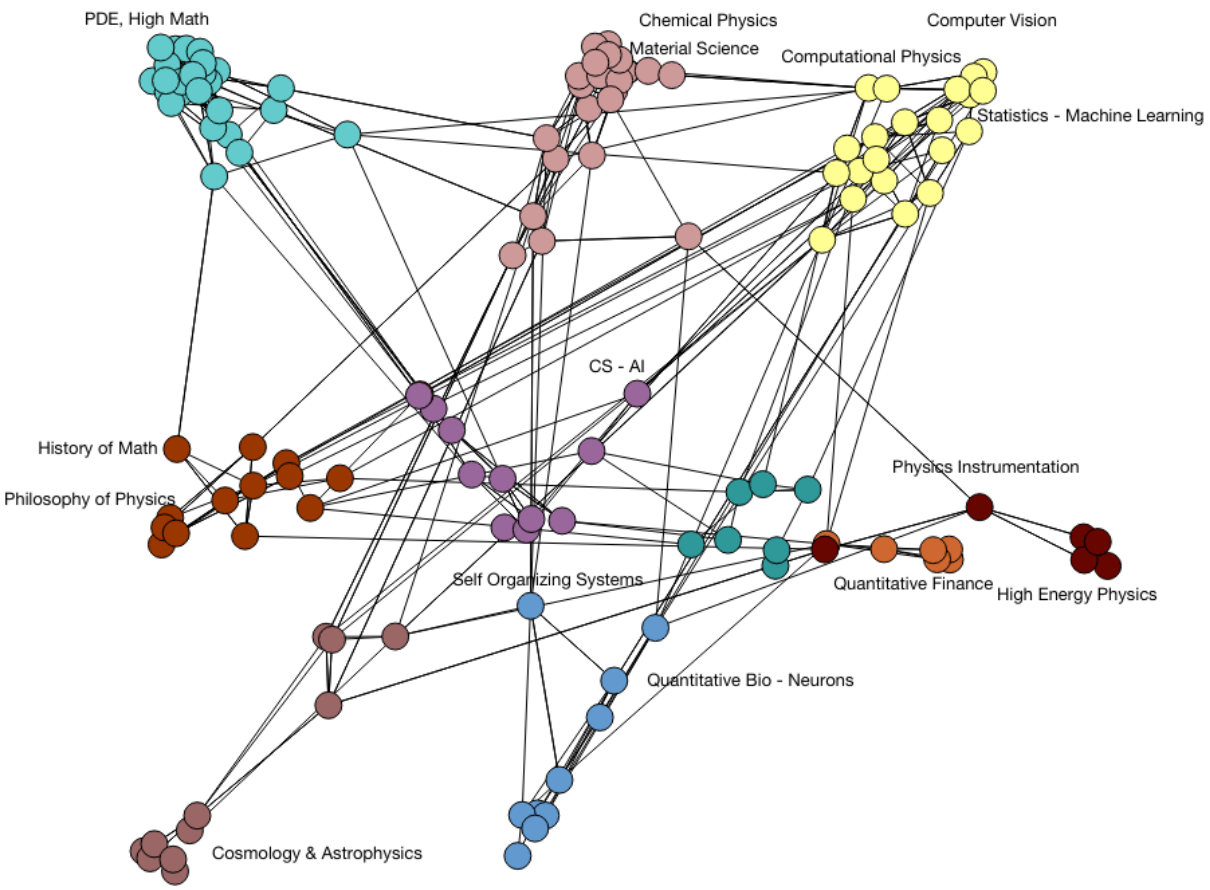


Visualised over time, we would be able to see an learner's **knowledge journey**. This could also serve as a way for others who may be on similar **knowledge journey** or those who were looking for a change. You would be able to correlate someone's life work or occupation to their **knowledge journey** and eventually begin to find and cluster similar journeys that could emerge through unsupervised learning leading to whole new subjects or journeys that others could follow.

In this essay, I will propose a new way to approach education which will require significant effort to bring to life but I believe the benefits will surely outweigh the costs. I'll talk about how we can use machine learning and deep learning in particular to help create and support our knowledge cosystem which includes a **digital knowledge footprint**, **knowledge journeys**, and a collective human knowledge graph. We will also introduce current trends in deep learning and a novel neural network that would allow us to take the space of unstructured educational content and begin to map it unto the human knowledge graph, use generative models to make educational content engaging, and test a learner's knowledge through questions and answers, no what matter the subject. I will name a few benefits of such a future.

- A society where learners do not simply compete for a degree but where they can feel safe to create their own unique journey through human knowledge and still be recognised and predictable to others
- A society where an learner's knowledge is derived not from what we know about a degree but by their actual knowledge which is alive and therefore always evolving
- A society that better understands itself, through the understanding of the many journey's it's members have taken and the collective knowledge that has gone mostly unaccounted for in today's degree based education.

I will also show that this imagined future is not only **desirable** for society but also that much of it is currently feasible mainly due to the most recent advances in machine learning, and in particular deep learning, which will enable us to begin designing such a future today.

Chapter 2

Concepts

Digital Knowledge Footprint

The concept of a digital education footprint is is a custom symbol and profile that represents one's education relative to that of others. Each symbol should be somewhat unique and the profile could capture the general education as well as the intricacies.

A symbol which represents somethng as complex as one's education will likely not be enough for employeers and co-workers to understand the . A symbol must show that one is in a particular "class" while also Symbols generally have to make trade-offs

Knowledge Journeys

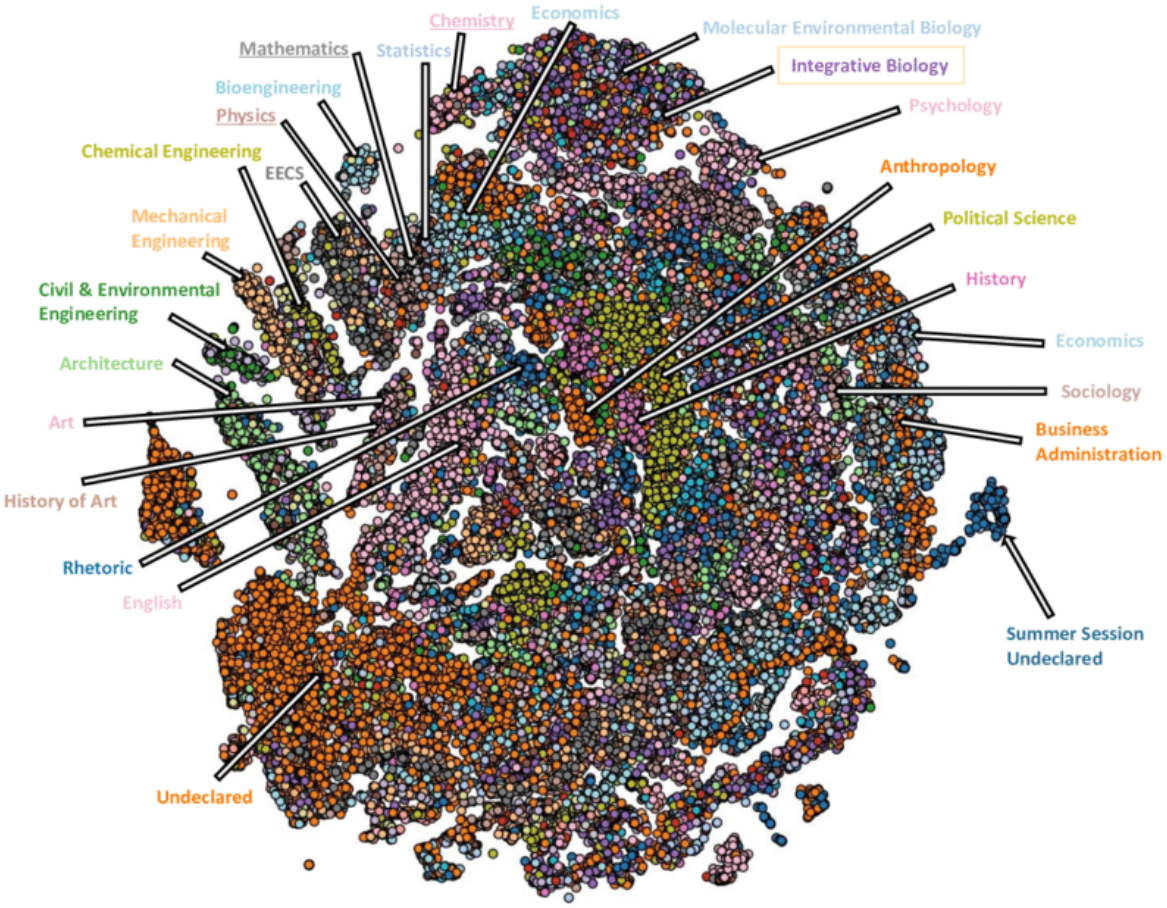
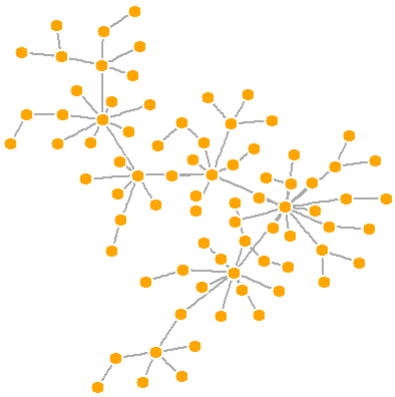


Image src: https://www.researchgate.net/figure/t-SNE-projection-of-the-embedding-of-all-learners-in-the-dataset-Major-labels fig1_323391033 between the complexity of what it represents and it's ability to convey , the legi from dealing with the task of reduction of info. So we introduce **Journeys** which show how someone has traversed the uy If most people had their digital education footprint, they would be

Collective Human Knowledge Graph



The knowledge graph will be the backbone of a learners journey through human knowledge. As a learner continues to consume educational content, their fingerprint

as wethe learner watches new content they extend their knowledge graph either stre current links

We have so far introduced **knowledge footprint** and **knowledge journeys**, which claim to be the right elements to synthesise one's education while capturing the complexity on one hand and making the learner relatable and predictable on the other hand. But how does one create a path? From video to video? From topic/subject to topic/subject? If so, how might a machine decide on the correct topic(s)? We have had plenty of advances in topic models but perhaps what we actually need to combine topic models with a graph of human knowledge. This graph, like Google or Wolfram's knowledge graph, should be generated both from the current structure of education and also driven by the unsupervised learning of new topics/subjects that do not currently exist within our current structure.

This graph would be useful so content on the web could be easily mapped to the graph adn relate one user to another as well as create trails.

Deep Learning Applications in Learning and Feedback

Summary

EC2QA Network - a novel network for educational content to questions and answers

The last piece we'll introduce here is a novel artificial neural network that would allow us to take any unstructured educat

Chapter 3

Primary Concerns

There are 3 popular concerns that I will attempt to address in this article about online learning in the present and the future. I will attempt to address them here and in the implementation section below.

- The first concern is that the learning is often passive
- The second concern is that the information remains untested and therefore doesn't truly make the leap from information to true knowledge.
- The third concern is that even if the two concerns above were met definitively, it would not be possible to .

Passive Consumption

It has been argued and shown in some studies[insert studies], that many people who consume videos or other forms of educational content online, especially when outside the context of school, are often consuming the content passively. This leads to what a colleague called "swiss-cheese learning", where one learns a bit here and there, lacking any real rigour or depth providing very little probability of capturing the major concepts or mastering the content in any adequate sense.

This is a concern that is widely observed. Passive watching is not equivelent to learning. There are many variables that are related to this including those that are cultural and biological.

Here I'll focus on two points. I argue that educational content online expects the content to help a learner reach a particular goal. There is nothing in the content itself, or the platforms, that reach out to reinforce or to verify the knowledge one has gained.

I will argue that some key elements of these features that these issues are Engagement can be increased if x, goal directed behaviour can be enhance by small learning goals.

- Engagement
- Goal-Directed

  People watch videos casually and on the fly—and they rarely turn their phones sideways to do it.
  - Facebook Ads

Untested Knowledge

It has been argued that it is hard to verify what someone has learned while consuming educational content online. This is generally true outside of those content producers who combine content and testing (i.e. Khan

Academy, Udacity, Coursera) but they are generally limited compared to the vast amount of videos that are available that lack this testing.

The knowledge

Predictability

Concerns #1 and #2 can be solved and it could serve the learner who is seeking to master the content of a particular or several subjects. An learner could find themselves engaging with the goal of mastering the subjects, knowing that their grasp of the knowledge would be tested.

But it does not solve the societal issue. If you are like myself, you have watched more videos and read more articles online than you did when you were in school. Possibly much more. But how does one make sense of such consumption since it is largely unstructured and from various learners and institutions. Let us take degrees and their success in making an learner's ability predictabe. A degree not only makes an learner predictable, in fact, it makes a whole class of learners predictable on one crucial dimension. When we know one has a BA in Mathematics we know that they should have some knowledge of mathematics. We can imagine that an learner with such a degree has working knowledge of a familiar set of subjects (even if one doesn't know much about mathematics) and also the type of work they might be able to do. This is because of the traditions of our educational institutions and practices. The predictability is due to our past knowledge of what a particular subject is about and the occupational outcomes of such knowledge. The bad part is that degrees are beginning to tell less and less of the story. So for all of it's ability to reduce the complexity of gained knowledge, it is too limiting to represent a user's true level of knowledge.

Chapter 4

Towards an ecoystem of teaching machines

So how would a universal teaching machine eclipse these challenges? We will present a solution that meets all three criteria by introudcing a theoretical artificial network architecture to cover the first two.

neural then cover each concept in detail. Our idea of a digital education footprint, journeys, and a knowledge graph will provide us with what we need to take a first stab at encompassing a learner's whole education by addressing the three concerns.

In order to take all of our videos

The components

A component of a universal teaching machine should be able to take any of the billions of educational content online (and eventualyl off) and by using machine learning and deep learning techniques complete the following: - assign it to a one or more knowledge subjects (i.e. math, design, computer science) - generate a set of adequate questions and answers that test the learner's (what is x? a, b, c, or d) knowledge throughout the learning session

Over time, it is plausible, that our digital education footprint would be the most important representation of an learners level of education. Even more important than our primary education; it has done much to make us predictable, but it has sacrificed the true range of an learner's gained knowledge and wisdom coming from any other place than the institution is willing to give credit for.

Since we've largely rely upon large institutions to educate groups of learners, many have grown deeply familiar with having a perfectly demarcated path towards a degree, so it has been much harder for learners to use this abundance of knowledge to chart their own educational journey in today's fast moving world.

being us how to the peer pressure of cohorts, self-learning learned Imagine that if you signed up for a job, your primary consideration and also your digital education could be conveyed as a path through the web that others attempt to follow or mix and match. Now let us imagine a world where our digital education fingerprint allowed us to

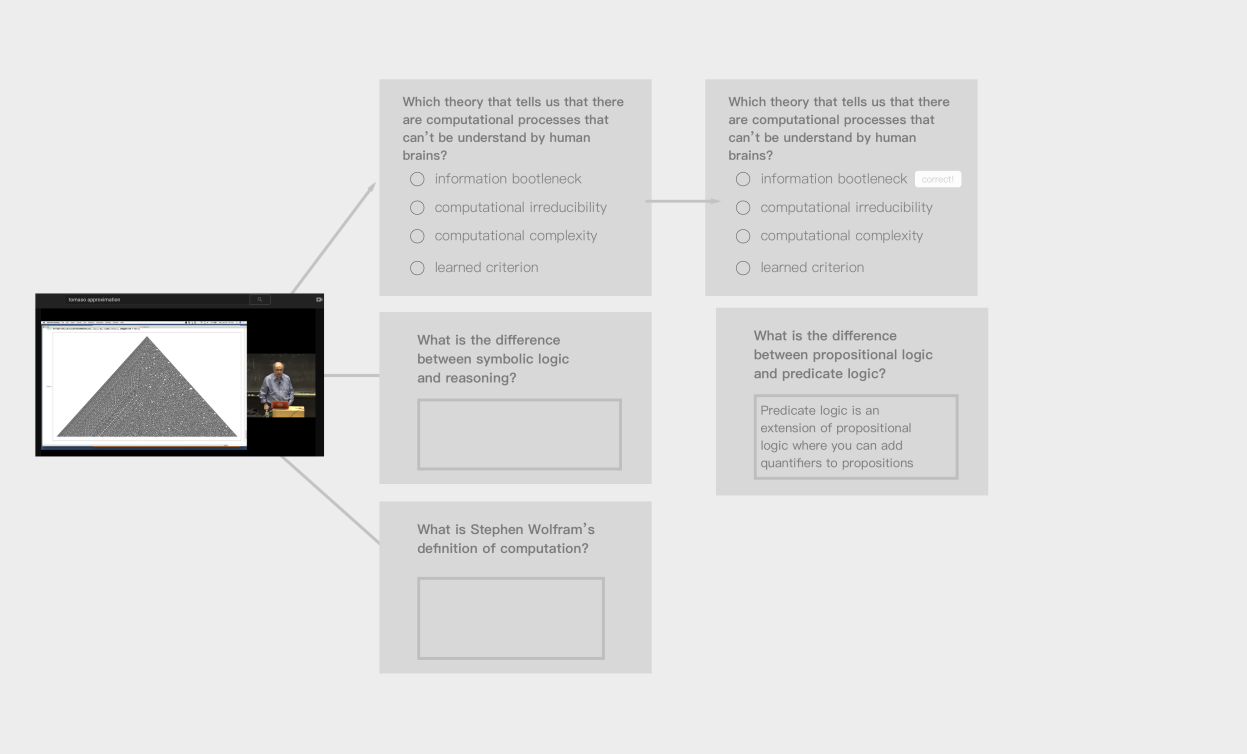


Figure 4.1: Image title

Chapter 5

Theories for statistical learning theory and deep learning

Theory of the learnable Mutual Information (IT) Joint probability

Chapter 6

Implementing a Teaching Machine

Placeholder

Problem Formulation

Why deep learning?

Before we start...

Question Generation

Answer Evaluation

Close-ended Questions

Dual Question-Answering Model

Open-ended Question

General Question

Specific Question

Summary of Learning and Feedback Networks

Summary of Knowledge Graph

Summary of Learning and Feedback Networks

Summary of Current Research and Needs