EECS 598: Artificial General Intelligence

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Contents

1 What is Intelligence? Definitions (Jan 5)

[26] Shane Legg and Hutter Marcus. Universal intelligence: A definition of machine intelligence. 17(7):391–444, 2007

> This paper does a great job at attempting to define Intelligence. I have never thought that Intelligence could be defined but I understand why this is needed to attempt to create AGI. H Woodrow stated, "The capacity to acquire capacity" which sounds like a great answer to the question of what is Intelligence. I enjoyed this paper because I am interesting not only in AI, but also how it is built programmatically. I read this and wonder how in the world that is going to be implemented in a bunch of 1s and 0s and be fast enough. That is definitely an important Future work.

[33] Stuart J. Russell. Rationality and intelligence: A brief update. 2013

> I find it interesting that more study and implementation of AI is in the form of Mathematical Models. I mean this in the sense that I know they are used know because it is currently what we understand and know how it works. But it's very obvious to see that the future of AI will consist of a model that connects it's neurons exactly how our brain's neurons work. This obviously will take a substantial amount of biology research but if understood, could be implemented in a binary computer that may work slow, and then a quantum computer and someday in a biologically build Brain-like Processing Unit.

2 What is General Intelligence? Definitions and Requirements (Jan 10)

[23] John E. Laird. Intelligence, knowledge & human-like intelligence. 2020

> I love your definition of Intelligence and Rationality. I don't just agree with this importance when it comes to AGI or AI, but I love it as a concept of human behavior and human judgment. I think that many are judged because their processor is slower than others and it causes self doubt and people thinking they are dumber. But really they just don't have the same available knowledge as those around them, but that's no excuse to stop growing your available knowledge. Sorry for the rant.
>
> Along with that but more to AGI, I think a human intelligence takes in consideration the time it has to make the decision and comes up with "TOP" factors that could relate to the subject. Then combines the probable outcomes with possible actions to determine the action(s) with the least loss/negative outcome. This is how I feel knowledge should be used in AGI. No pre-selected columns and weights. More like, what columns of the data do I think are most relevant, and how much weight should I put on them.

[15] Ben Goertzel. Artificial general intelligence: Concept, state of the art, and future prospects. 5, 2014

> This paper brings up the concept of Generalizing when it comes to symbolic thought. This made me think about the level of generalization we want in the AGI models. Becuase I understand that we make a lot of decisions based on the most likly thing and that most likely is basically a generalization. But sometime the world goes round because of the crazy unpredictable decisions that humans make. I bring this up becuase I think at a current implementation we'd just want to build an AGI model that doesn't need to make unpredictable decisions. But think of the oportunity that one would have with an AGI with the ability to not only think about a decision to make but even decide to confuse their opponent or something like that.
>
> Computational Neuroscience is something that sounds like one of the most important aspects of AGI. If we can copy how our brains are able to make these decisions we will get much closer to AGI. That is in two different ways though, one in the concept of how our brains model and generalize things and learn, two how our brains save data in order to load it back so quickly. I'm curious what the possibility is that our brains don't do a Preprocessed model but more a Live processed model. Meaning all our 6 senses ever do is read and write data. While in runtime our brain gets that data makes a model of it an compares it and then makes the decision based on the data not a generalized model of the data.

3 Animal Intelligence (Jan 12)

[28] R Lindsay. Understanding understanding. chapter 2. 2012

> "There can be no doubt that the difference between the mind of the lowest man and that of the highest animal is immense." This quote by Charles Darwin introduces an understanding of how far humans have come and how far we still need to go in order to develop a true AGI system. Because the fundamental problem to solve with an AGI system is to build it to learn and possibly not only learn but create an unconscious desire to learn more. This is something that I believe eludes most animals and is their reason for not improving as much as humans.

[2] S. S. Adams and S. Burbeck. Beyond the octopus: From general intelligence toward a human-like mind. in theoretical foundations of artificial general intelligence. pages 49–65, 2012

> The idea that Octopi are asocial creatures and that is why their knowledge dies with each one of them, is an incredible realization and understanding. I find this fascinating in an example of how the human race as grown as much as it has. When it comes to AGI, I see how this can be useful information because I know that many of the Deepmind's AI's have been built on playing against other AI's and other people. I find it interesting to wonder if making multiple slightly adjusted AI's to then learn from each other could be the optimal solution to AGI and further maybe even after that if one is better than the other we can use that one in production.

[9] Frans B.M. de Waal and Pier Francesco Ferrari. Towards a bottom-up perspective on animal and human cognition. trends in cognitive science. pages 201–207, 2010

> I wonder how some of the ideas in the paper would be implemented in code. Such as possess a theory of mind, culture, linguistic abilities, future planning, etc. I think it would be so much fun to attempt. In the section "Imitation" I started to wonder if there can be someway of masquerading that. Such as proposed in the last article. Score Keeping was mentioned in the article and I wonder what the possibilities are in a competing system that compares not only it's outputs to real world scenarios but also to itself and other AGI's. Meaning that it would be competitive against other AGI's in order to win.

4 Human Brain as a Machine (Jan 19)

[16] R. Granger. Toward the quantification of cognition: What kind of machine is a human brain? 2020

The work done in this paper really brings out the importance of Research based on physical things such as the Neocortex, Cerebellum, Straitum, Septum, and other things like Cortical-subcortical loop circuitry, and the hippocampal loops.

These areas are important to understand how a brain processes input and what occurs in the brain itself. I think that the Section 'Thesis B.3) Brain circuitry predominantly consists of cortical-subcortical loops' explains the need to pre-process this input data to then be used in the brain.

One large part of AGI is not only finding AGI algorithms but also finding the compute power/compute systems. Our brains are different than current implementations of computers, and I would say that computers need to mimic the brain's compute abilities more closely in order to replicate the brain's ability to do AGI.

One thought that this paper has spun up in my mind, is how close are other primates from being able to process what we can? I mean this in the way that, we assume that apes are very close and that they may just need a subtle push. But I hypothesise that Human brains are built just different enough to support that ability to learn and grow, where as other animals may not need time to develop them, but never will.

5 Foundations of Cognition Science (Jan 24)

[32] A. Newell. Unified theories of cognition, chapter 2: 2.8 & 2.9; chapter 3: Human cognitive architecture. 1990

I remember a couple of papers ago I mentioned my thoughts on what if the brain does less of building a model in run-time when data is gathered, and maybe data is just saved and then the model is generated on "Search" of the data, and then it is compared and used when a decision is being made.

The thought of not knowing what to do next makes me wonder about the innate things that humans do everyday that may or may not have not been taught to us but more just naturally done by humans. I wonder what possibilities there are in adding a system or bias to do default things that we would call natural.

6 Human Cognition Core Systems (Jan 26)

[18] K. D. Kinzler and E. S. Spelke. Core systems in human cognition, progress in brain research. 16, 2007

I believe I mentioned this in a recent paper writing about how there may be a lot to AGI and human thought/learning that comes naturally. This paper touches on the concept that "humans are endowed with a small number of separable systems that stand at the foundation of all our beliefs and values." This creates a large problem for AGI when it wants to become so much like a human. Without this it just has to be modeled to do what humans would most likely do in a given scenario.

The fifth system that identifies in- and out- group members doesn't sit well with me. It doesn't seem like that is an innate action naturally occurring in the average day. As I say that I see that animals may possess it but I SEE IT MOST AS A GROUPING BASED ON the fundamental emotions of love, happiness, safety. And social groupings are just constructed by the need for those things and who can provide then,

7 Embodiment (Jan 31)

[3] L. W. Barsalou. Grounded cognition. page 617– 645, 2008

Having put a lot of thought into how maybe a descriptive analysis might be created/programmed. I can't help but think that this cannot be a finite thing. That there needs to be a system that can classify things recursively in a way that it may classify things as living creatures but that is not the end of it's understanding(As stated in the Van Elk Paper). It further understands that there are more sub-classifications done like walking on two legs and walking on four, Animal and Human, etc. This I feel would need to be recursive in nature, meaning that it would have to create those classifications on it's own once it is told or understands that there is a difference. I think of how a child knows the differences. It is simply told sometimes that a cow is not a human. And that it cannot communicate. Therefore it can add those labels to it's understanding of what a cow is.

8 Representation (Feb 2)

[8] E. Davis and G. Marcus. Commonsense reasoning and commonsense knowledge in artificial intelligence. pages 92–103, 2015

I think the common sense issue is an interesting one, due to the fact that I don't see a large need for it in the current market and world of AI. But that is because most all decisions of that sort might be able to just be implemented in code.

This makes me think of what common sense really is, because in our world we seem to think that common sense is this understanding of what the answer should be without having to think to much about it. But in the example of the Dad holding the Baby and asking which is which could be thought of as common sense as in which is bigger, but I would argue that it could be an argument that "which is bigger" is the learned question to ask yourself in order to understand the answer, then your brain actually does compare the heights. This Question may have been based on the attempt of multiple questions to ask in order to find out the answer, like having a beard.

9 Common Sense Reasoning and Understanding (Feb 7)

[37] Yixin Zhu & Tao Gao & Lifeng Fan & Siyuan Huang & Mark Edmonds & Hangxin Liu & Feng Gao & Chi Zhang & Siyuan Qi & Ying Nian Wu & Joshua B. Tenenbaum & Song-Chun Zhu. Dark, beyond deep: A paradigm shift to cognitive ai with humanlike common sense, engineering. pages 310–345, 2020

Common sense is somewhat defined in this paper as the ability to come up with a, "that makes the most sense" answer when using small amounts of data. This would have to be a way of creating super generalized responses to problems instead of making bad predictions/decisions. What I mean by that is some small data models are not able make good decisions based on the lack of data, and therefore make crazy decisions because the model was unable to fully understand what was going on.

I wonder if this can be achieved through, (at a high level), instead of starting weights off at 0 or random but maybe in the middle of the possible data points. Meaning for a specific feature we get the weight that would predict the middle of the max and min (of ave) of the training data and then while training the data we start off at a great generalized stop. Then as we are training we penalize the function based on it's distance from that middle ground. I feel this would allow for a more general idea of the data and not allow for crazy predictions/decisions.

10 Analogy (Feb 9)

[14] Forbus K.D. Gentner D. Computational models of analogy. wiley interdisciplinary review cognitive science. pages 266–276, 2011

> Analogy in computing brings me back to what I'm always curious about when it comes to this stuff. Is it really a fancy thing that our brains are doing? Or is it just our brains/ ourselves that is just learning after a long time of failure that it is easier to understand things by comparing it to similar situations.
>
> I am curious if the way to build this model or attempt to get a model like this would be to give it an error or it's timing. Meaning that it would use how long it took itself to come up with the answer as a loss function.

[30] M. Mitchell. Abstraction and analogy-making in artificial intelligence

> I feel like this is really an attempt to construct a recursive amount or models that make up your one AI model. What I mean by this is if you teach a non-english speaker the word bridge and point at a physical bridge, they would not know what you mean all the other times you used the word bridge. Once they heard it being used in a different context and verified it was not a mistake. I believe that the brain would not just add the definition of the word bridge to it's definition of the word bridge. But maybe it would take the original definition and find similarities. Similarities need to be defined as things/words that seem to have the same definition to the sentence. Like structure.

11 Meta-cognition and Theory of Mind (Feb 14)

[6] M. T. Cox. Metacognition in computation: A selected research review, artificial intelligence. pages 104–141, 2005

> I like the second part of making a choice, "thinking about your thinking" I think that this is a very important part of thinking. I think that is society though this amount of time is more of a personal belief than a fact. Because really things can go on and on forever and you can think about things for a long time. Considering Religion, I would argue that a lot of religious people are so distracted thinking about what to say and what to do to help other believe in the religion that they end up spending less time thinking about their own thinking of the subject. Also, there are a lot of Religions due to that fact that not everyone has enough time to keep thinking about it. So time, desire and availability are all large factors in what religion people may end up in.
>
> I really don't like the model depicted in Fig. 3. of the world and Modeler alternating within each other. The reason that I don't want to agree with this is because it doesn't allow for two things that are unrelated to be compared and grow a relationship. Which is a huge part of our previous papers on Analogy.

[20] et al Kralik, J. D. Metacognition for a common model of cognition. 2018

> perceive-decide-act, I really like/am ok with this model of cognition. But I have to wonder about "analysis". Meaning a post-act observation of what happened after the action was taken. This I think is almost as important as perceiving and deciding. I think that analysis could be defined as perceiving and deciding but in a post act sense like perceive-decide-act-perceive-decide. Where the first perceive and decide look for past experiences and try to make a decision based on that and the current situation.

12 Emotion (Feb 16)

[36] S. Thill and R. Lowe. On the functional contributions of emotion mechanisms to (artificial) cognition and intelligence. 2012

> It's crazy to sit back and go through what actually would motivate a perfect AI model from moving or making any decisions if it were to start with all knowledge or even no-knowledge. I'm talking about the motivation behind getting up in the morning. A computer will probably never be able to feel things, but we can make it think that it is by comparing what it should be feeling. But no matter the emotion that the computer things it's in. It may never do anything. That is were an in-ate desire to do good, learn, or build things comes in for humans. I wonder how that (drive) can be implemented into an AGI.

[27] et al. Lerner, J. S. Emotion and decision making. 2015

> I keeping trying to think of a way to not only implement human emotion in an AI model but more how can we get the model to understand other peoples human emotions. NLP, Computer Vision. and then (at least at first) tell it what "Good" is. Like, you want to weight the outcomes and one may be the emotional effect on the people involved. This being, it needs to predict that the person is going to become more satisfied after they do something.

13 Types and Levels of Learning (Feb 21)

[24] P. Langley. Human learning: The computational gauntlet of human-like learning. 2022

> I am forced to think abut how I learn the best, which is in my living room pacing back and forth contemplating the days events or the things that I'd like to know more about. I think that AI/ML and AGI are too focused on run-time/immediate results, when really we sleep and we take breaks and we think about things all the time. This is all part of concept of Post-processing or Thinking after the fact. I think that if we want to build a good model we need to understand that it may not make the right decision the first time but maybe when it's taking a break it can think about the outcomes and the data it has in order to think about what it should do differently next time. And this would also bring up the important topic of being able to make simulations in the brain to determine potential outcomes and determine the one you'd/it'd want.

[10] Laird J. E. and S. Mohan. Learning fast and slow: Levels of learning. 2017

> If the challenge is to learn how humans learn than you would need to understand why humans learn at all. I think that that is the fundamental part of what makes humans so unique and advanced when it comes to learning. We love to learn but we need to know why. One reason is fight or flight, meaning it is a survival technique. But if that's the case the really we are just built not to want to die. And from there we find the best ways to live.

14 Cognitive Architecture Overview (March 7)

[25] P. Langley, J. E. Laird, and S. Rogers. Cognitive architectures: Research issues and challenges. 2009

It was interesting in the implementation Soar, All tasks in Soar are formulated as attempting to achieve goals. I can't seem to process the implementation of this in code. Because everything that I am currently familiar with uses weight and biases not using Goals and I'm curious how those goals are computed/represented.

15 Common Model of Cognition (March 9)

[22] J. E. et al. Laird. Standard model of the mind. 2017

I think that a standard model is always a good idea but I wonder how confident we are that the current model architecture is close to optimal architecture. Or if we think that there could be a new architecture that could possibly come up. As it says, the key ingredients are Artificial Intelligence, cognition, Neuroscience, and robotics. I feel that the most important one is the understanding of Neuroscience and how the brain processes data. I think that if we focus on the functions of the brain and how thought is saved and computed using the brain.

16 Common Model without Cognition (March 14)

[35] R Sutton. The quest for a common model of the intelligent decision maker. 2022

I'd just like to note that though this paper is shooting for a different approach on decision-making, It's still important that the model have a Goal. I'd love to think of a model that would not need a goal, but that doesn't seem feasible because that is a fundamental part of these models. I comment on this to show the simplicity to which one can define a model, "learning to achieve a goal". I can't actually think of what my brain/AI would be able to do without a grasp on the world around it. I often don't know fully what's going on in school or situations until I process it for myself and put it in context.

17 Soar (March 16)

[21] J. E. Laird. Introduction to the soar cognitive architecture. 2022

The episodic memory holds a history of previous states, while semantic memory contains previously encountered facts. I wasn't sure when each is used but I like episodic memory more due to the fact you can understand the past exactly.

When the model doesn't have enough knowledge about the system it says that it creates a new goal to know which operator is should pick. I think that this is a great way of doing it but I am curious of it's time table. I wonder if the chunk would be able to optimally perform if it was only training during down time.

18 ACT-R (March 21)

[5] Anderson J.R. & Betts S. & Bothell D. & Hope R. & Lebiere C. Learning rapid and precise skills. pages 727–760, 2019

> I see how this is such an important part of the AGI because the brain does the same thing. The brain isn't just one model that makes a decision based on it's surroundings but it uses different parts of the brain to come up with decisions. I think that ACT-R is in the right direction for that, but I think that there is more to the brain that is not understood and therefore is not properly implemented yet in AGI/ACT-R

19 Neuro-Inspired Models (March 23)

[29] Hassabis D. & Kumaran D. & Summerfield C. & Botvinick M. Neuroscience-inspired artificial intelligence. pages 245–258, 2017

> I think I've commented before about home much I agreed that if we really want to create a true AI then we need to model our brains and the Neuroscience behind it as much as possible. I feel that there is something that is often overlooked, are Neural Networks the solution or close to the solution of a NeuroScience AI. Or are they just a working hack that is working really well right now and hopefully be useful when we get to a hardware point that is similar to the brain's hardware, but NN's won't be the driving engine at that point. I feel like there's defiantly more to the story and that might only be discovered when we come up with the hardware needed but before then NN's will just have to do.

20 SPAUN (March 28)

[7] Eliasmith C. & Stewart T. C. & Choo X. & Bekolay T. & DeWolf T. & Tang Y. & Rasmussen D. A largescale model of the functioning brain. pages 1202–1205, 2012

> Semantic pointers are neurally realized representations of a vector space generated through a compression method. I think that this is a great way to represent the brain because we have to make decisions very fast an we can use these to make decisions to the best of our "semantic knowledge" and then later if we feel that that decision could have been different and want to learn from it then we add new data to the database and learn/train the semantic weights more with that new data. We run into a problem when the AI made a real-time mistake and needs to classify that as something that it should want to learn from or not.

21 LEABRA (March 30)

[1] O'Reilly R. C. & Hazy T. E. & Herd S. A. The leabra cognitive architecture: How to play 20 principles with nature and win! page 91–115, 2017

In Principle 8 they talk about the neocortex and the role that it and many other parts of the brain play in cognition. I think that this hasn't seemed to be in discussion as much, we have talked a lot about maybe building a cognitive architecture that would be able to perform and model the brain. But this got me thinking and wondering how much computation is actually being done by all the many parts of the brain and then pieced together at the end and then a decision is made.

This would be a very hard task but I think that it makes sense to do because we don't really know what the overall goal is for each model. I feel that this is would allow us to break it up, and each part would have it's own agenda and lean towards that outcome. This would in-turn result in a personality of outputs.

22 Neuro-Turing Machines (April 4)

[4] Mark Collier & Joeran Beel. Implementing neural turing machines. 2018

I don't know much about MANNs but I have heard of and used a LSTM Network and I loved it's ability to remember the most recent of data in order to make a prediction based on the most recent data. I have always wondered if things like this could be mimicked by using some sort of Moving Average. But I guess with this explanation of that it has to save out memory in order to remember what's happened it kind of already is like that.

"We find that the choice of memory contents initialization scheme is crucial in successfully implementing a NTM." While I'm a little confused still on what Memory Contents actually are, The implementations seem to be good implementations. I wonder if there is an optimal solution such that in training and testing there could be a constant initialization in order to be able to compare other parameters and find optimal solutions to other things. And then in production the Learned initialization could be used to find the most optimal initialization.

23 Model Building vs. Pattern Recognition (April 6)

[34] Lake B. & Ullman T. & Tenenbaum J. & Gershman S. Building machines that learn and think like people. 2017

> Similar to the last report I claim there is a lack of influencing a goal in the model. But I think that that can be somewhat overlooked when the paper starts to go into learning-to-learn. Which can be argued as a similar thing to goal setting. I think that most of my life up to this point has not only been learning but looking for things to learn. If the model is able to successfully learn-to-learn then it is setting goals to further it's understanding.
>
> If I may go off topic for a minute, I wonder what benefits this could introduce in the real world where learning-to-learn is somewhat neglected in schools. If elementary was able to help kids learn how they personally learn the best, they would be able to do better in their higher education and potentially enjoy it more. This would in turn allow the AI world to see a human representation of learning-to-learn and possibly run tests and find the best way to do so computationally.

24 AI-GAs (April 11)

[17] Clune J. Ai-gas: Ai-generating algorithms, an alternate paradigm for producing general artificial intelligence. 2019

> I think that the thought of computationally using AI to try and find the best AI or AGI is a great step. But I wonder if there is a strong middle ground for this author. I think that we might be off on being fully able to produce AGI from AI but maybe there is a set of instructions to create that may point someone at the stage of discovering each of the pieces. These instructions could be a guide that might help get the person to the next step to finding that extremely complex machine.

I did 25(April 13) and 26(April 18) anyway

25 Task Learning (April 13)

[19] John E. Laird & Kevin Gluck & John Anderson & Kenneth D. Forbus Odest Chadwicke Jenkins & Christian Lebiere & Dario Salvucci & Matthias Scheutz & Andrea Thomaz & Greg Trafton & Robert E. Wray & Shiwali Mohan & James R. Kirk. Interactive task learning. pages 6–21, 2017

> Task Learning is creating a model that has the ability to learn multiple things and execute them as good or better than a human can, I think that this is a fundamental part of AGI and needs to be implemented in the final and perfect AGI model that we are looking to find. But I think that we should be more open to a modeling structure that is a little less black boxed. I mean this like our brains. Our brains seem to be a black box of information and we don't understand how it's making computations and making decisions and then all the sudden we have the answers. but i think we may be overlooking the complexity of our brains. There are a lot of different functions of our brains that work together and it is not just one black box that learns all these different things.

[11] Mininger A. & Laird J. E. A demonstration of compositional, hierarchical interactive task learning. 2022

> That's so cool that Rosie was able to acheive such high understanding of the different tasks and perform them so well. I think that the cross task understanding is key, where Rosie was able to use the "the concept of three-in-a-row, which can be learned for Tic-Tac-Toe and then used in Three Men's Morris".

26 Future Implications – what is going to be possible in our lifetimes?? (April 18)

[13] R Fjelland. Why general artificial intelligence will not be realized. 2020

> One part of the argument of what weak/strong AI is and isn't is the models ability to do things and classify things very generally. I think there is an important part of this that is often not talked about which is the fact that the AI need to become Narrow minded and not general in certain tasks that it knows are correct. This can be in different implementations such as when training/past data has pointed one way or when the model needs to make a decision in a split second, it needs to have more weight on making the best decision that it can without thinking if it needs to learn more or not.

[31] M. Mitchell. Why is ai harder than we think? 2021

> Fallacy 1: Narrow intelligence is on a continuum with general intelligence. I've thought often about this topic and not letting myself get caught up in something that I think is a step in the right direction but really it is only somewhat in the right direction. When it comes to AI and AGI, i think that this is the best approach. We will not get to the optimal solution tomorrow because we don't need it tomorrow. If we progressively update our systems to use more and more complex AI models we will be ready for the day we get the best AGI. But for now if we had it we wouldn't even know what to do with it.
>
> That is why improving our AI towards what we need right now will help us stay afloat for now and therefor we will be ready when we finally crack the code.

[12] Adams et al. Mapping the landscape of human-level artificial general intelligence. 2012

> The Scenario for Assessing AGI, General Video-Game Learning, is by far one of the best scenarios due to it's implementation in the world. There is tons of data on Video-games and gamers. And you'd be able to get a lot of people to love to compete against the AI in the game. Similar to Alpha Go.
>
> The other Scenario Preschool would be great due to the fact that they would be able to help younger students later on. The research and things learned there would be able to help the next generation in their learnign.

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