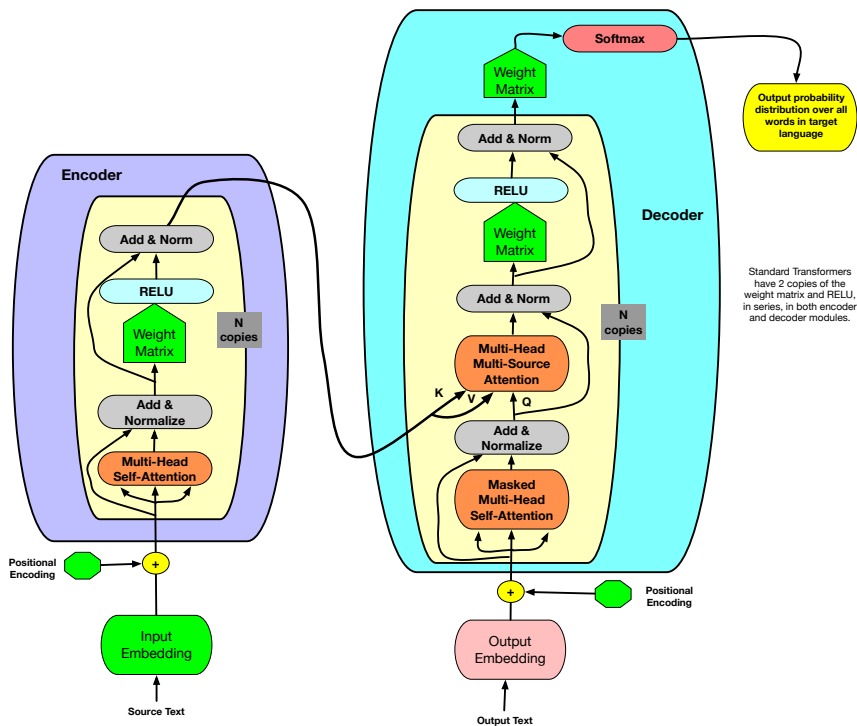# Artificial Intelligence
Master Studies
at IDI / NTNU

Some Gray-Haired AI Professor
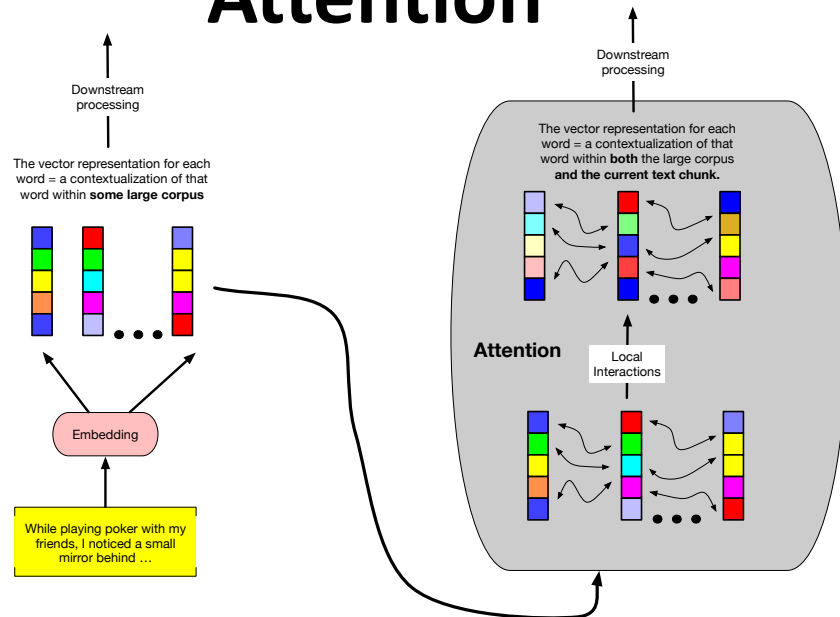
Data and Artificial Intelligence Group (DART)
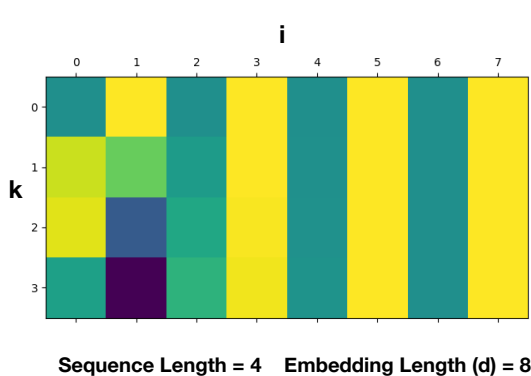
Transformer

Encoder

Add & Norm

RELU

Weight Matrix

N copies

Add & Normalize

Multi-Head Self-Attention

Positional Encoding

+

Input Embedding

Source Text

Softmax

Weight Matrix

Add & Norm

RELU

Weight Matrix

Add & Norm

Multi-Head Multi-Source Attention

K V Q

Add & Normalize

Masked Multi-Head Self-Attention

Decoder

N copies

Standard Transformers have 2 copies of the weight matrix and RELU, in series, in both encoder and decoder modules.

+

Positional Encoding

Output Embedding

Output Text

Output probability distribution over all words in target language

Attention

Downstream processing

The vector representation for each word = a contextualization of that word within **some large corpus**

Embedding

While playing poker with my friends, I noticed a small mirror behind …

Downstream processing

The vector representation for each word = a contextualization of that word within **both** the large corpus **and the current text chunk.**

Attention

Local Interactions

Embedding

i

P(k,i)
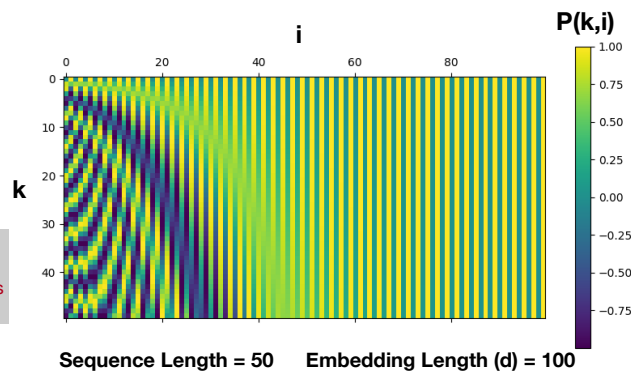
k

Sharp oscillations due to alternation of sin and cosine along each row.

Oscillation frequency increases vertically (with k) and decreases horizontally (with i)

Sequence Length = 4   Embedding Length (d) = 8

i

P(k,i)

k

Sequence Length = 50   Embedding Length (d) = 100

**Answer:
The guts of
ChatGPT
(as best
we know)**

Me: Write a 6-line poem to welcome new AI students in the style of a Norwegian weatherman.
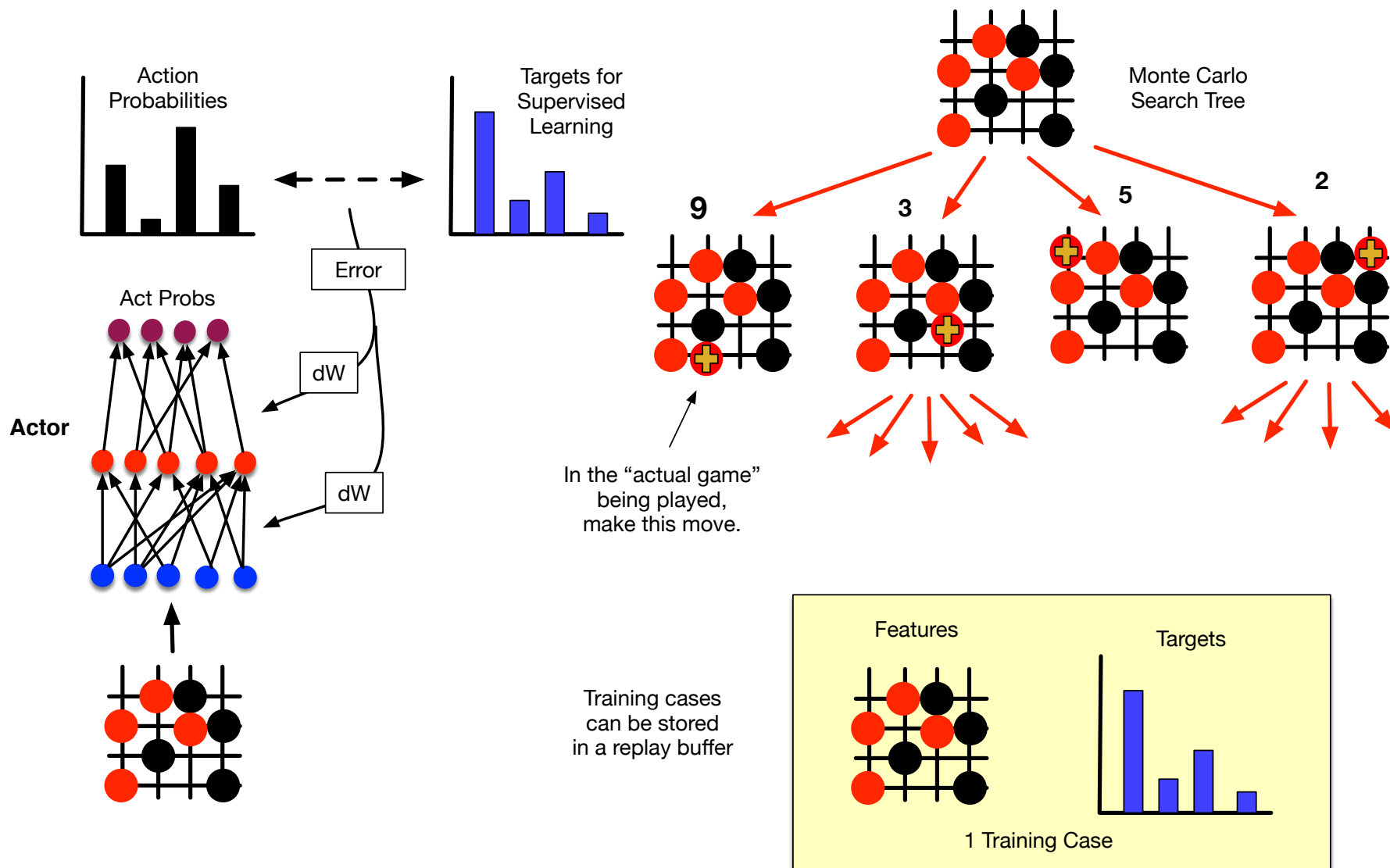
ChatGPT (3.5):

Greetings, budding minds, to AI's embrace,

As code and circuits intertwine in grace.

Like fjords and forests, mysteries unfold,

In algorithms' dance, a story yet untold.

With neural skies and data's winds to steer,

Welcome, students, to AI's frontier!

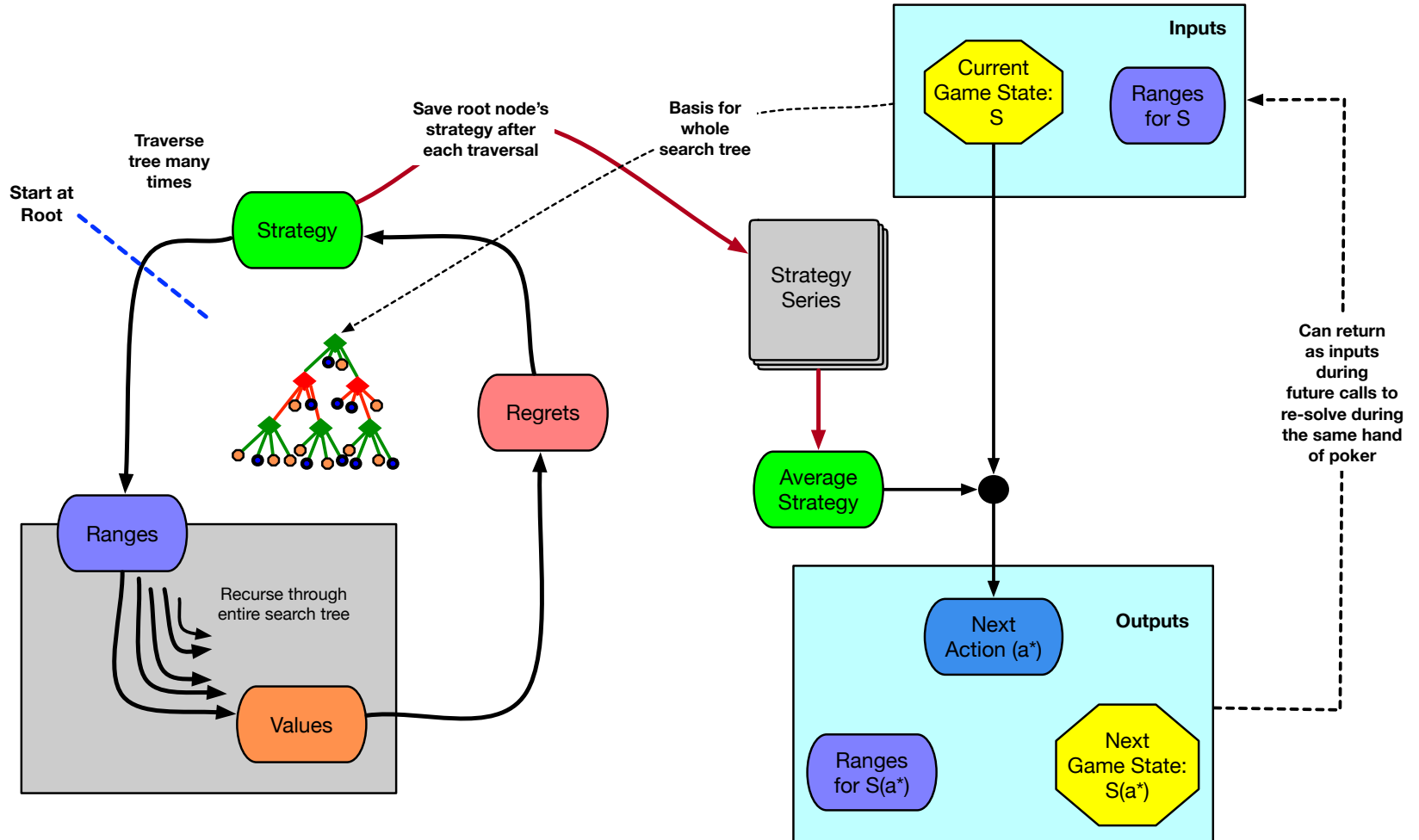**Me:** Could you make it a little less welcoming and a little more threatening?

ChatGPT (3.5):

Beware, newcomers, to the realm of code,

Where AI's power and mysteries erode.

In tangled circuits, secrets may arise,

As algorithms weave their cunning lies.

Dark currents lurk beneath the digital sky,

Forge ahead, or in shadows you may lie.

AlphaGo (2016)

Action Probabilities

Targets for Supervised Learning

Monte Carlo Search Tree

Error

dW

dW

Act Probs

Actor

9   3   5   2

In the "actual game" being played, make this move.

Training cases can be stored in a replay buffer

Features
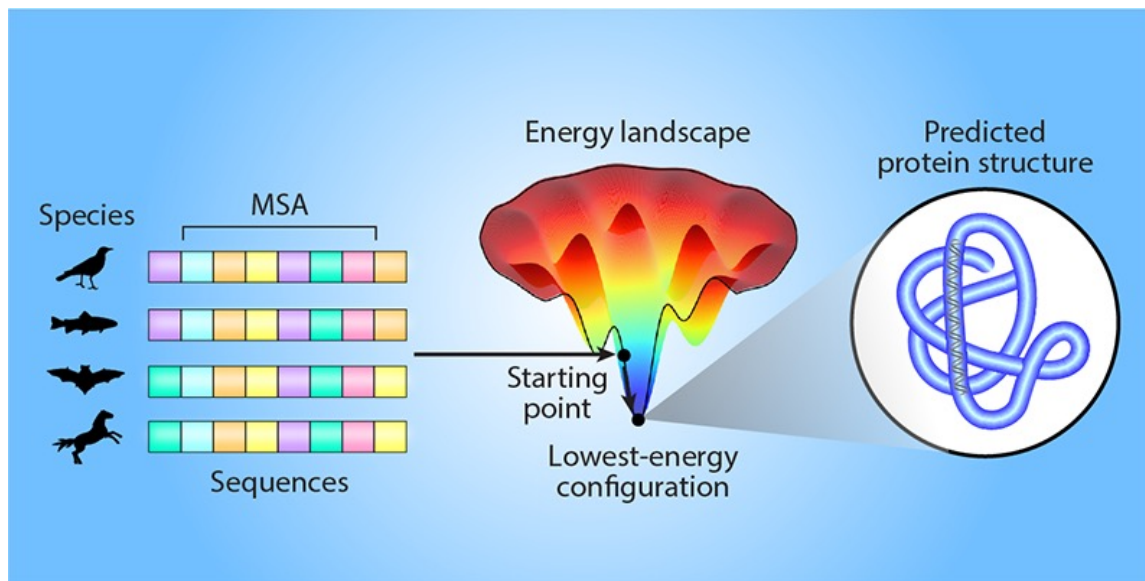
Targets

1 Training Case

DeepStack (2017)

AlphaFold (DeepMind, 2020)

Given: a nucleotide sequence (which directly codes for amino acids)
**AlphaFold Computes:** 3d structure of the resulting protein = How the amino-acid sequence **"folds".**
Implications: A protein's 3d structure determines its physicochemical behavior.

- A process that once took **years** (e.g. one PhD per protein) now takes **minutes**.
- 200 million proteins on earth, with many discovered each year, but few have known 3d structures.
- AlphaFold => Huge knowledge gain + **massive labor savings** !!

AlphaGeometry & AlphaProof (DeepMind, 2024)
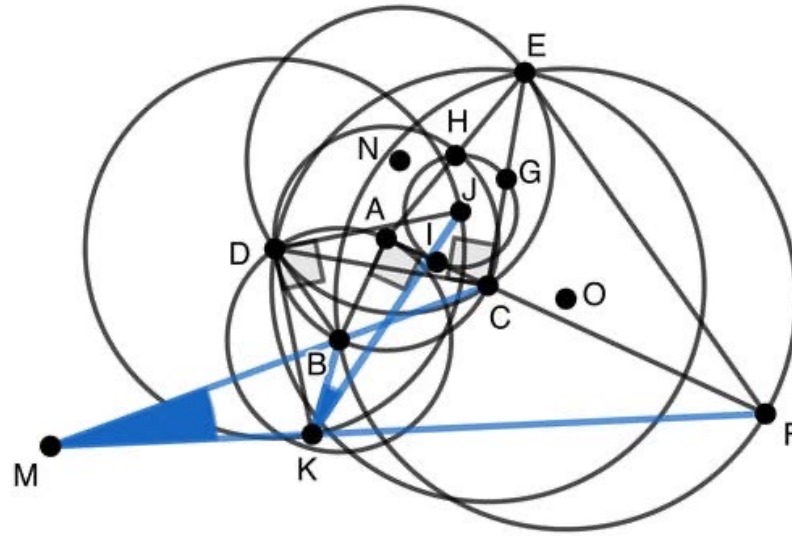
Creativity = Introduction of extra objects: points, lines, triangles, circles..

Traditional Symbolic AI Theorem Prover + Large Language Model

Silver Medal in Math Olympiad

Artificial Intelligence (AI)

Logic-Based Systems

Natural Language Processing

Machine Vision

Case-Based Reasoning

Machine Learning (ML)

Search-Based Systems

Deep Learning

DRL

Reinforcment Learning

Planning Systems

Decision Tree Classification

Evolutionary Computation

Deep Reinforcement Learning (DRL)
E.g.:
AlphaGo / AlphaZero / AlphaFold
DeepStack
ChatGPT

Fields Beyond AI

AI's Recent Popularity

Good News / Bad News

[+] Employers want AI students for their AI skills, and not just as clever programmers

[-] They don't really know what AI can / cannot do

[-] Competition for spots in AI Master's program

[+] There's some AI in ALL of IDI's study lines.

AI skill = understanding + building, not just using.

Words from The Masters

"... there is currently a <u>war for the scarce AI talent...</u>"
+ "AI is the new electricity."
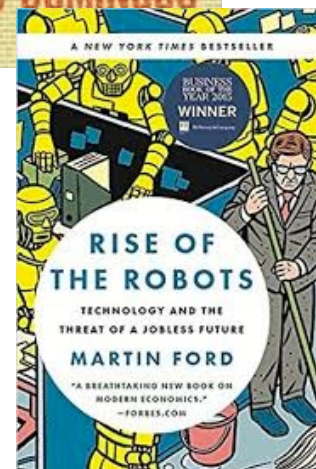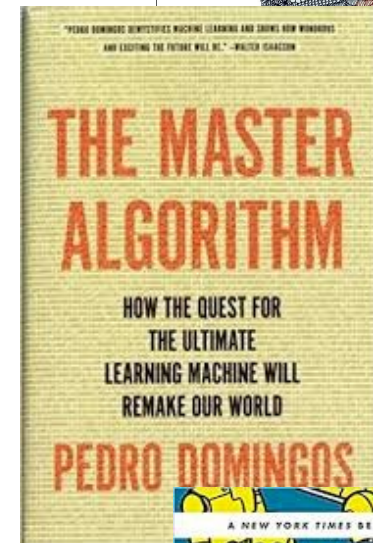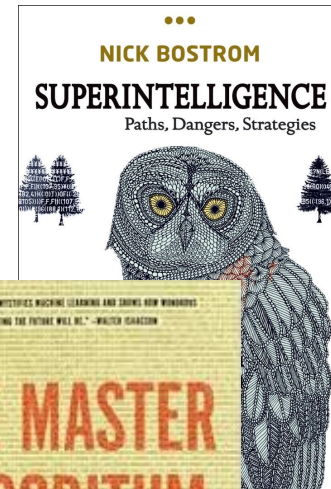**– Andrew Ng**, Professor at Stanford

"The rise of powerful AI will be either the best or the worst thing ever to happen to humanity. We do not know which." – Stephen Hawking, famous physicist.
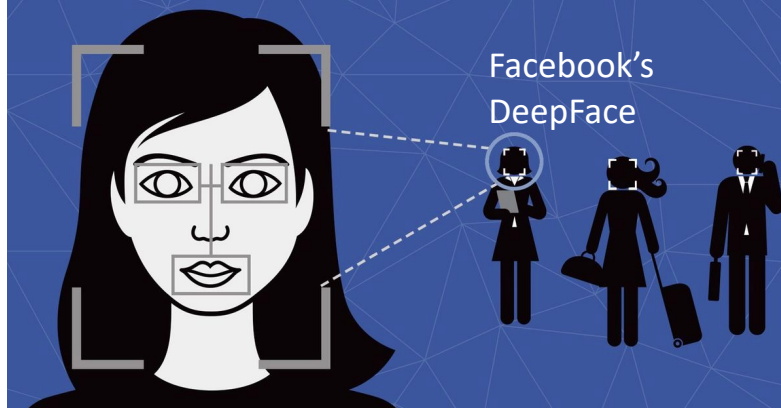
"If you don't learn AI, you're going to be a dinosaur within three years." – Mark Cuban, famous US businessman.

"You won't lose your job to an AI, but you might lose it to someone who knows AI." - **Scott Galloway** (popular tech podcaster)

"In the algorithmic dark, we lose our way. And the machines we built become our prey." -- ChatGPT (when asked to provide an AI quote in the style of Bruce Springsteen's (dark) Nebraska album).

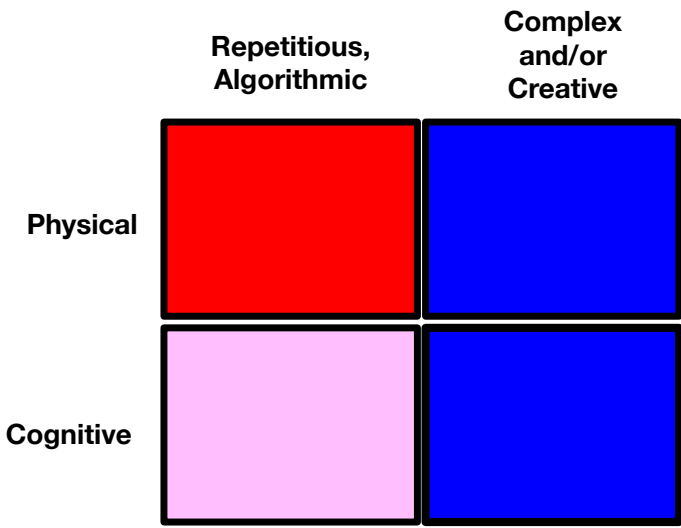The big tech companies now compete to build THE AI platform (Chatbot?) of the future.

NICK BOSTROM
SUPERINTELLIGENCE
Paths, Dangers, Strategies

THE MASTER ALGORITHM
HOW THE QUEST FOR THE ULTIMATE LEARNING MACHINE WILL REMAKE OUR WORLD
PEDRO DOMINGOS

A NEW YORK TIMES BESTSELLER
RISE OF THE ROBOTS
TECHNOLOGY AND THE THREAT OF A JOBLESS FUTURE
MARTIN FORD

Facebook's DeepFace

OpenAI

ChatGPT

Hey Siri, is the weather nice in Lake Tahoe today?

NEWSPAPERS

FICTION   NON-FICTION

- Science –vs- Science Fiction of AI
- Today's AI systems: facts -vs- hype

$3,400 $4,400 $1,200

KEN   WATSON   BRAD

ALPHAGO 00:56:41

Google DeepMind Challenge Match

人機世紀之戰

3/9-3/15

LEE SEDOL 01:03:24

Move 37!

解說員介紹：
林聖賢老師－職業八段 圍棋技藝指導老師
高川格－圍棋評論家 圍棋頻道經營者

	Repetitious, Algorithmic	Complex and/or Creative
Physical	■	■
Cognitive	■	■
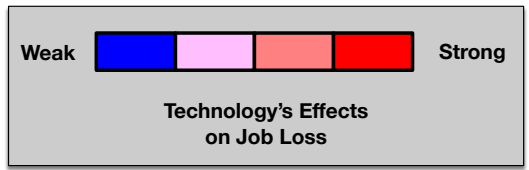
Classic Technological Disruption

Weak ■ ■ ■ ■ Strong

Technology's Effects on Job Loss

Physically Repetitious, Algorithmic	Physically Complex and/or Creative
Mentally Repetitious, Algorithmic	Mentally Complex and/or Creative

AI's Disruption

Hey Chat GPT, finish this building...
Your skills are irreplaceable.
IMPACT

AI-designed
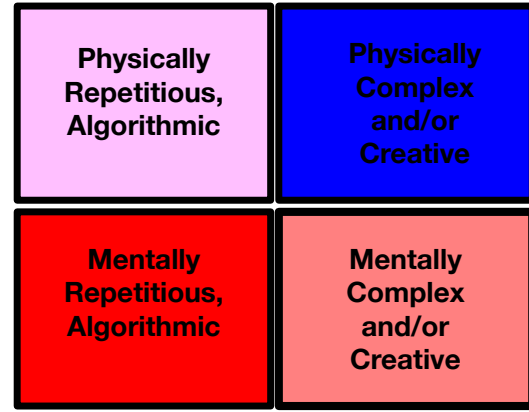
Plight of the Infovore

Constant distractions of cyberspace

↓

"Shallows": Reduced depth of thought and emotion

Less Creative

↓

Reduced value in an information society

Rely on computers to understand the world

Rely on AI for **wisdom**

Automation Bias: Trust machines over ourselves.

→

Human intelligence becomes **artificial** **...** and thus more easily **predicted** and **controlled** by AI

... as we come to rely on computers to mediate our understanding of the world, it is our own intelligence that flattens into artificial intelligence (Nicholas Carr, ***The Shallows***)

Popular AI Topics at IDI

- Deep Learning (Neural Networks)
- Natural Language Processing / Text Analytics
- Bayesian Decision-Making
- Case-Based Reasoning
- Evolutionary Algorithms
- Multi-Agent Systems / Swarm Intelligence

- What's in your toolkit?
- Today, AI is everywhere, and anyone can use it, but you need **special competence** to **understand** + **develop** it.
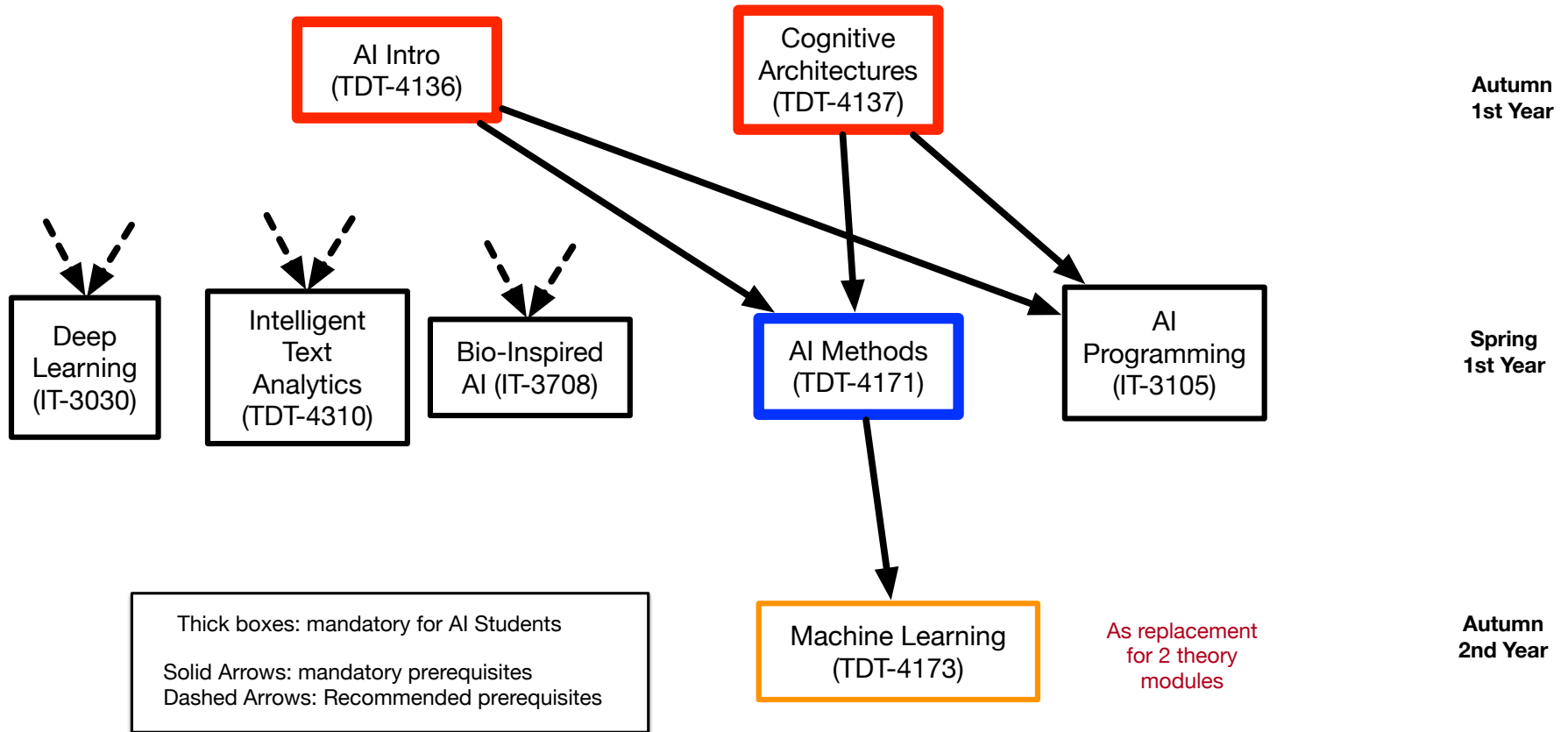- Lots of (fun?) programming.
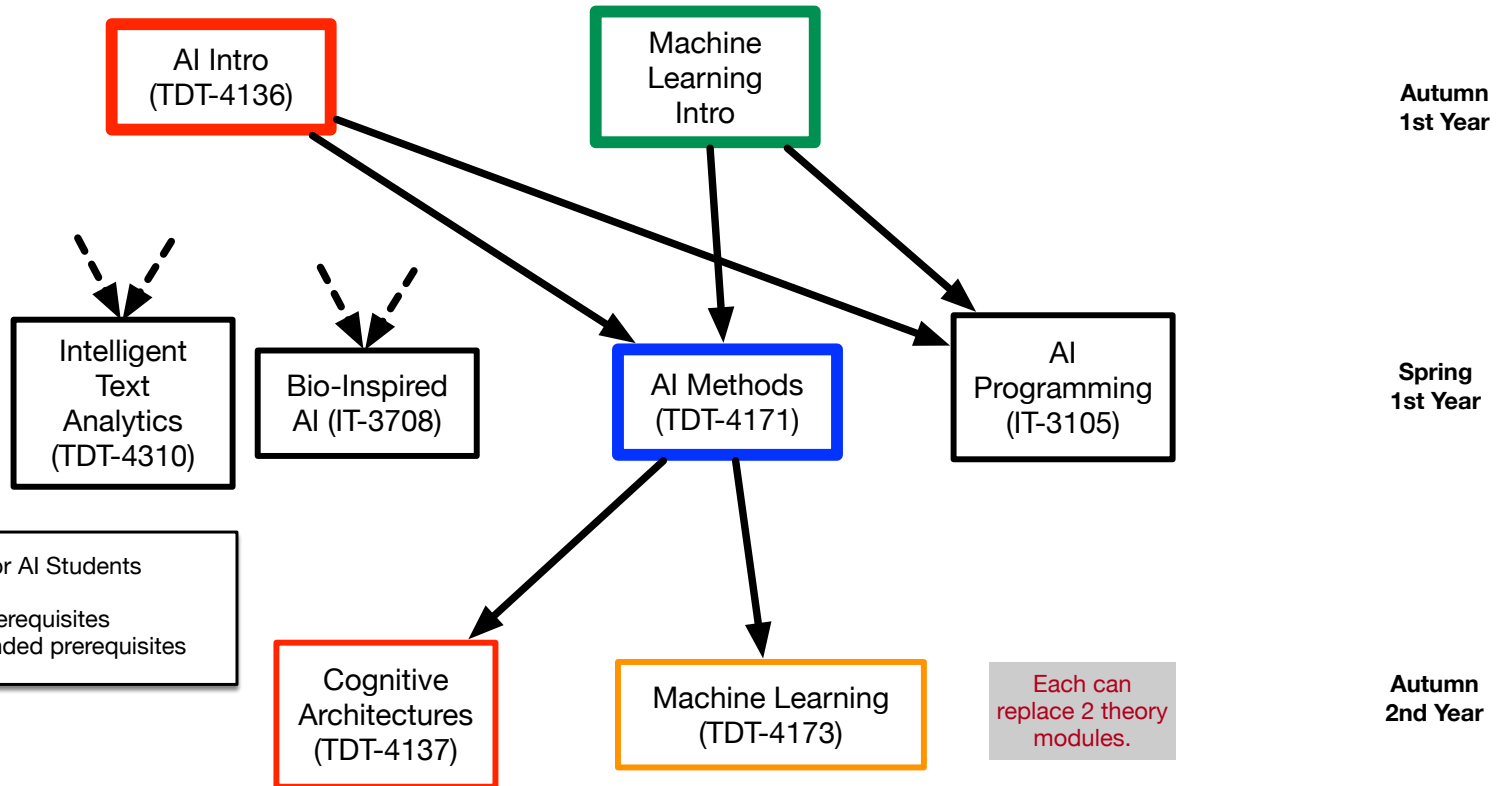
AI Course Structure (Through Spring 2024)
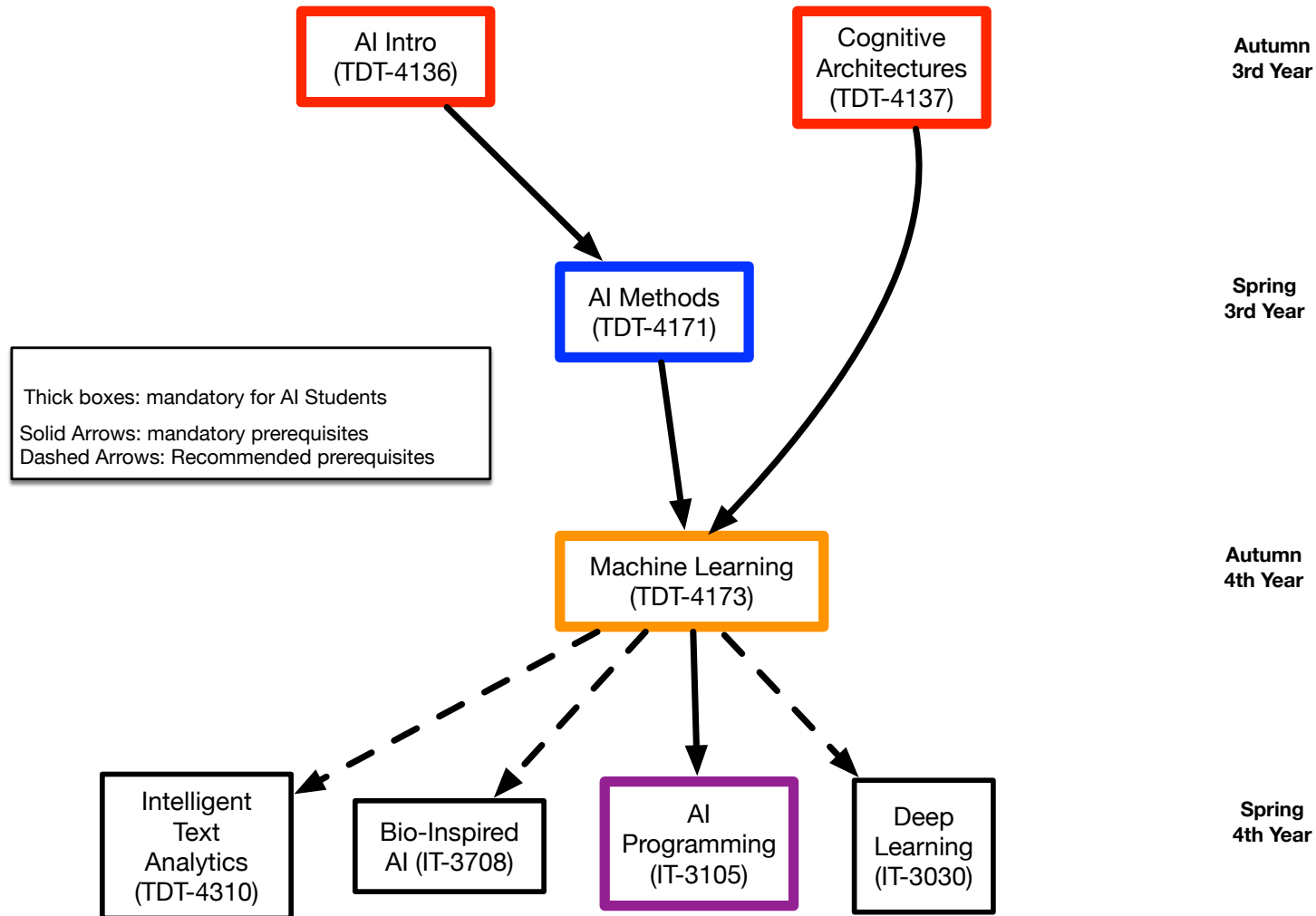
AI Course Structure (From Autumn 2024)
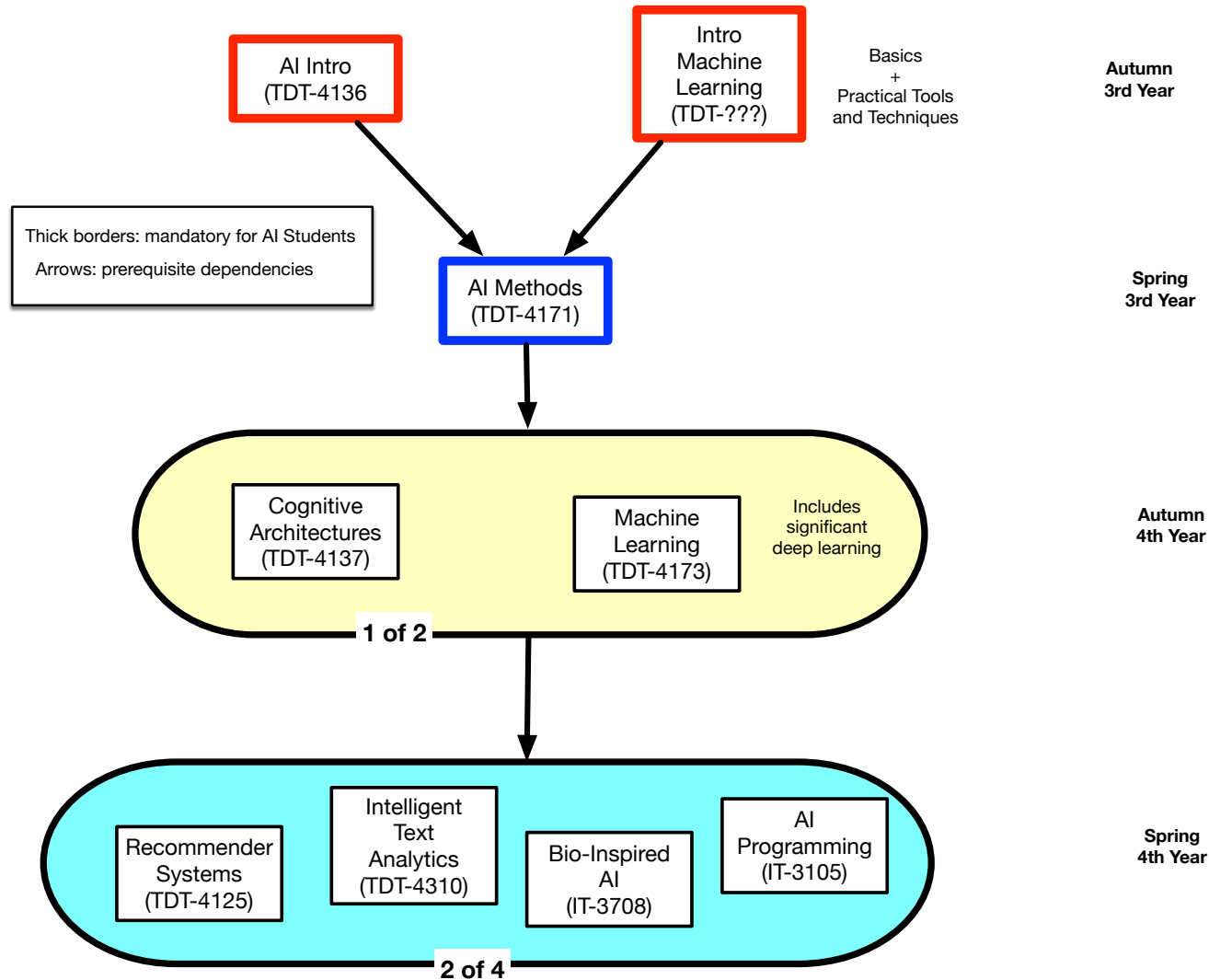
AI Course Structure for 2-year Master (to Spring 2024)

Autumn 1st Year

AI Intro (TDT-4136)

Cognitive Architectures (TDT-4137)

Spring 1st Year

Deep Learning (IT-3030)

Intelligent Text Analytics (TDT-4310)

Bio-Inspired AI (IT-3708)

AI Methods (TDT-4171)

AI Programming (IT-3105)

Autumn 2nd Year

Machine Learning (TDT-4173)

As replacement for 2 theory modules

Thick boxes: mandatory for AI Students

Solid Arrows: mandatory prerequisites
Dashed Arrows: Recommended prerequisites

AI Course Structure for 2-year Master (from Fall 2024)

Autumn 1st Year

AI Intro (TDT-4136)

Machine Learning Intro

Spring 1st Year

Intelligent Text Analytics (TDT-4310)

Bio-Inspired AI (IT-3708)

AI Methods (TDT-4171)

AI Programming (IT-3105)

Thick boxes: mandatory for AI Students

Solid Arrows: mandatory prerequisites
Dashed Arrows: Recommended prerequisites

Autumn 2nd Year

Cognitive Architectures (TDT-4137)

Machine Learning (TDT-4173)

Each can replace 2 theory modules.

AI Courses

- AI-1 (TDT4136; autumn)

- Cognitive Architectures (TDT4137; autumn)

- Machine Learning (TDT4173; autumn)

- Machine Learning Intro (starting autumn 2024)

- AI-2 (TDT4171; spring)

- AI Programming (IT3105; spring)

- Intelligent Text Analytics and Language Understanding (TDT4310; spring)

- Bio-Inspired AI (IT3708; spring)

- Deep Learning (IT3030; ending spring 2024)

- [Theory Models; 3.5 credits each; autumn]
  Applied ML, Advanced Bio-AI, Computational Creativity, Causal Modeling, Advanced NLP, AI for Time-Series Analysis…

Student comments:

- *De mest interesserte og dyktige studentene fra informatikk- og datalinjene flokker seg til disse AI emnene.*

- *Sett av mye tid til faget og du kommer til å lære kjempemye og faktisk ha det moro samtidig.*

AI Research Goals

NTNU

IE

IDI

DART

AI
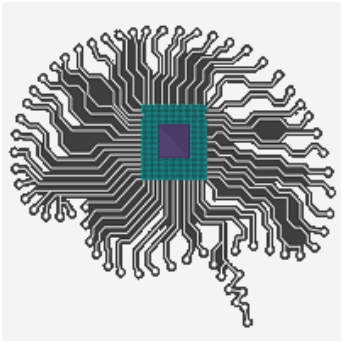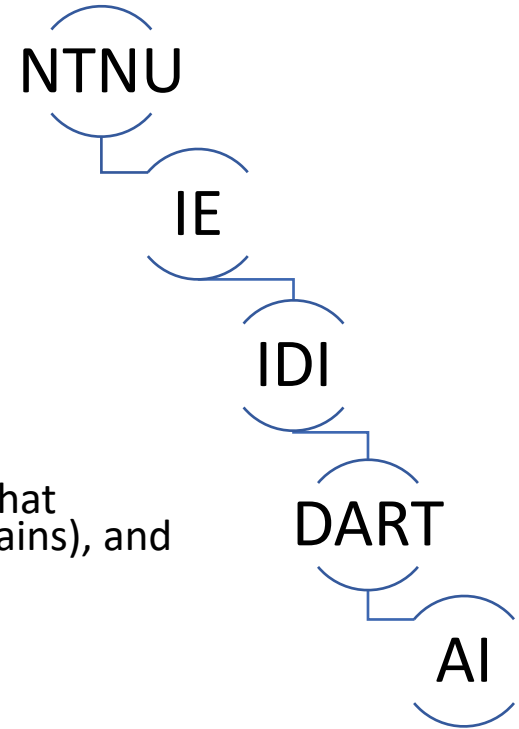
- ## Technological
  - Develop smart computer systems: those that behave intelligently (often in narrow domains), and which learn from experience.

- ## Scientific
  - Increase our understanding of intelligence (in general) in humans, other animals, and machines by designing computational models of sensing, reacting, reasoning and learning.

Recent AI Master's Theses

Build systems that problem-solve, learn, and/or self-organize
"Your project ➔ ***Your choice" [...within reason ☺]***

- Literature-based Knowledge Discovery in Climate Science
- Artificial Immune Systems for Detecting Fake News
- Flocking for Road Traffic Efficiency Improvement: A Concept Study
- Generating Blues Solos with Variational Autoencoders
- Deep Reinforcement Learning for playing Diplomacy
- Swarm Intelligence for Urban Transit Routing
- Deep Learning Classification of Bird Songs
- Human Activity Recognition with Bodily Accelerometer Sensors + Deep Learning.
- Decision Support for Exposed Aquaculture Operations
- Detecting Power-Line Faults with Drones and Deep Learning (Big Prize Winner !!)
- Computer Generated Poetry with Inherent Sentiment
- Deep Learning Facial Recognition (**of salmon**)

Same Procedure Every Year…

- Explore topics in your AI courses, online, etc. (3rd year)
- Read IDI's posted projects (spring semester, 4th year)
- Talk to teachers about projects
- Register project priorities online
- Handle acceptances and rejections (late spring semester, 4th year)
- Pick theory modules (early autumn 5th year)
- Define project in detail + investigate related work (autumn, 5th year)
- Deliver report on detailed project goals, background, related work, etc. (December, 5th year)
- Deliver final thesis (June, 5th year)
- Enter real world … make lots more money than your professors.

Some Useful Master Links

https://folk.idi.ntnu.no/keithd/ai-masters/ai-master-main.html

DART Teachers

Norwegian Open AI Lab

- A center for research, innovation and education within Artificial Intelligence
- Established in 2017, as Telenor-NTNU AI Lab with SINTEF
- Ensures collaboration between academia, industry and public sector
- Hosted by the Department of Computer Science, NTNU
- Strong NTNU research team, with a core team of 12 professors, 21 associated professors & 75+ PhD students

OUR PARTNERS

Projects
- Research
- Innovation

Students
- Master's theses
- PhD projects
- Student events
- Student organisations

Events
- Conferences
- Webinars
- Workshops

Education
- Master's and PhD education
- PhD summer school
- Continious education (EVU)
- Elements of AI

NorwAI

Center for Research-based Innovation

Enhance technology transfer, internationalization and researcher training through long-term research conducted in close collaboration between research-performing companies and prominent research groups.

Research and Innovation Areas

WP1   Management and communication

WP2   SOC: All in Society

WP4   PERS: AI for Personalization

WP5   LANG: AI for Language Technologies

WP6   STREAM: AI for Streaming and Sensor-based Data

WP7   HYB: Hybrid AI Analytics

WP8   DATA: Data and Platform for AI

WP3   TRUST: Trustworthy AI

WP9   AI Innovation Ecosystems

WP10   AI Innovation Areas

IA1 Explainability and verification

IA2 User modeling and behaviour prediction

IA3 Personalized and contextualized content creation

IA4 Predictive and prescriptive maintance

IA5 IoT sensor anomaly detection

IA6 Hybrid digital twins

IA7 Data Quality analysis and enchancement

RESEARCH AREAS

INNOVATION AREAS