MENG 3065 - MODULE 1

Artificial Intelligence: A Modern Approach – Chapter 1

Introduction

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Outline

- What is AI?
- A brief history
- The state of the art
- Ethics
- Coding Languages for Data Science

Kaplan and Haenlein

- Define AI as “a system’s ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation”

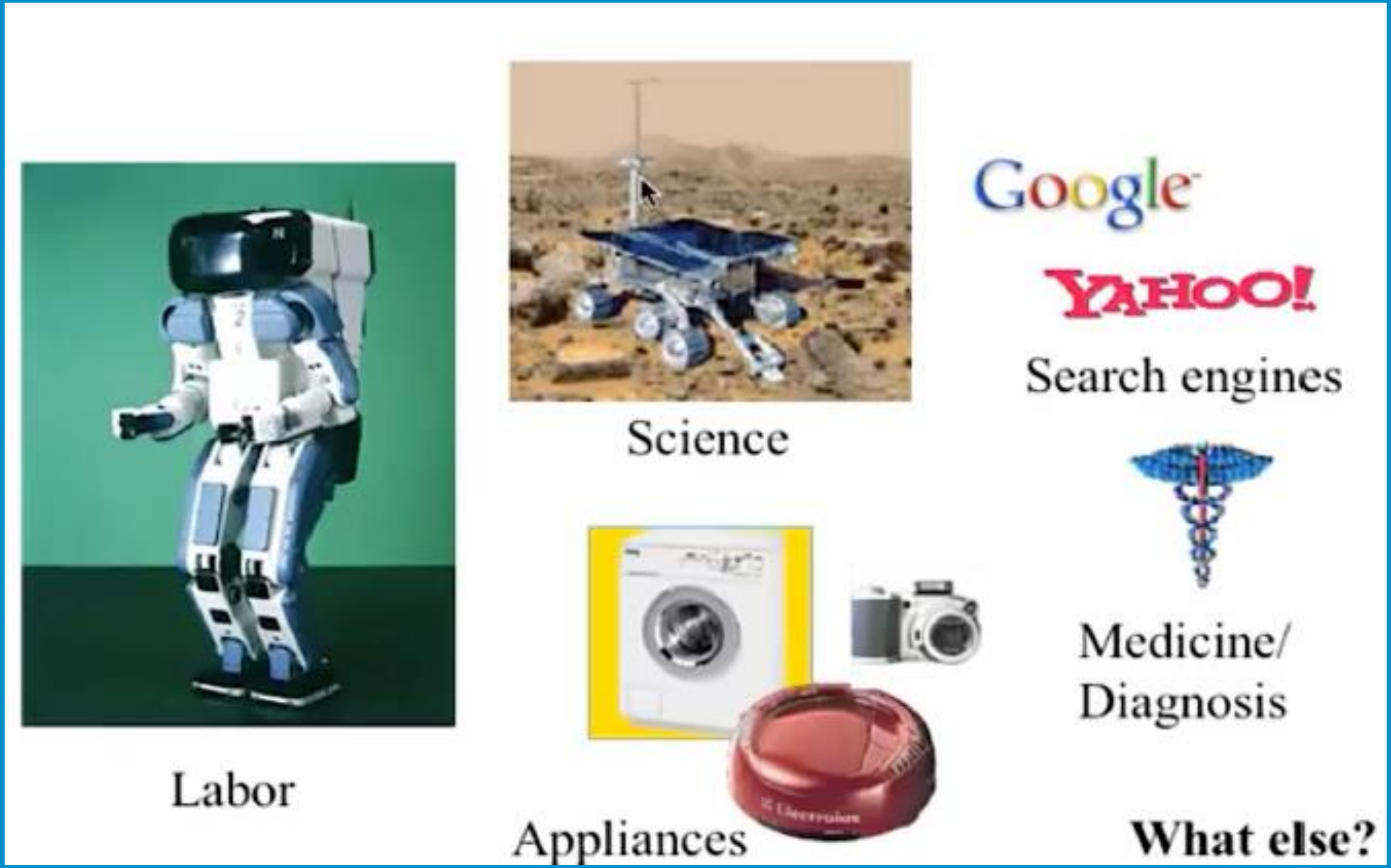
What Is Artificial Intelligence (AI)? THINGS you need to know

- Artificial intelligence, or AI, is a simulation of intelligent human behavior.
- It’s a computer or system designed to perceive its environment, understand its behaviors, and take action.

Poole and Mackworth

- Define AI as “the field that studies the synthesis and analysis of computational agents that act intelligently.” An agent is something (or someone) that acts.

Why study AI?



Google
YAHOO!
Search engines
Science
Labor
Appliances
Medicine/
Diagnosis
What else?

Why Does AI Matter?

- https://www.mathworks.com/videos/ai-for-engineers-building-an-ai-system-1603356830725.html

- AI is estimated to create $13 trillion in economic value worldwide by 2030, according to a McKinsey forecast.

What is AI?

- Systems that think like humans
- Systems that think rationally
- Systems that act like humans
- Systems that act rationally

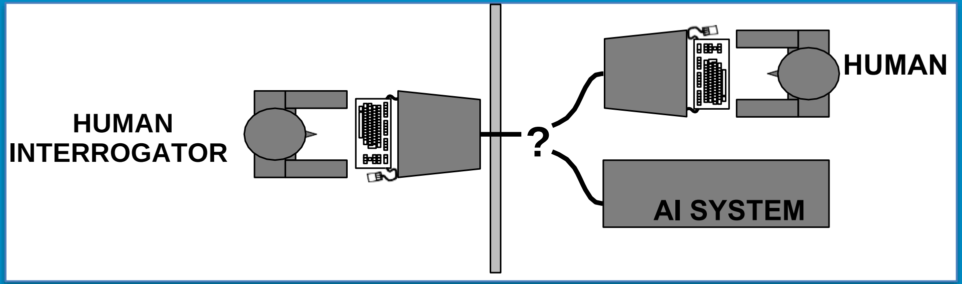
What is AI? (Cont'd)

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)
"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998)
"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Acting humanly: The Turing test

- Turing (1950) "Computing machinery and intelligence":
  - "Can machines think?" –→ "Can machines behave intelligently?"
  - Operational test for intelligent behavior:
    the Imitation Game



  - Predicted that by 2000, a machine might have a 30% chance of fooling a layperson for 5 minutes
  - Anticipated all major arguments against AI in following 50 years
  - Suggested major components of AI: knowledge, reasoning, language understanding, learning
- Problem: Turing test is not reproducible, constructive, or amenable to mathematical analysis

Thinking humanly: Cognitive Science

- 1960s "cognitive revolution": information-processing psychology replaced prevailing orthodoxy of behaviorism
- Requires scientific theories of internal activities of the brain
  - What level of abstraction? "Knowledge" or "circuits"?
  - How to validate? Requires
  1) Predicting and testing behavior of human subjects (top-down) or
  2) Direct identification from neurological data (bottom-up)
- Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI
- Both share with AI the following characteristic:
  the available theories do not explain (or engender) anything resembling human-level general intelligence
- Hence, all three fields share one principal direction!

Thinking rationally: Laws of Thought

- Normative (or prescriptive) rather than descriptive
- Aristotle: what are correct arguments/thought processes?
- Several Greek schools developed various forms of logic:
  - notation and rules of derivation for thoughts;
- may or may not have proceeded to the idea of mechanization
- Direct line through mathematics and philosophy to modern AI Problems:

  1) Not all intelligent behavior is mediated by logical deliberation
  2) What is the purpose of thinking? What thoughts should I have out of all the thoughts (logical or otherwise) that I could have?

Acting rationally

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking—e.g., blinking reflex—but thinking should be in the service of rational action
- Aristotle (Nicomachean Ethics):
  - Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good

Rational agents

- An agent is an entity that perceives and acts

- Abstractly, an agent is a function from percept histories to actions:

  – $f : P^* \to A$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

- Caveat:

  – Computational limitations make perfect rationality unachievable

  $\longrightarrow$ Design best program for given machine resources

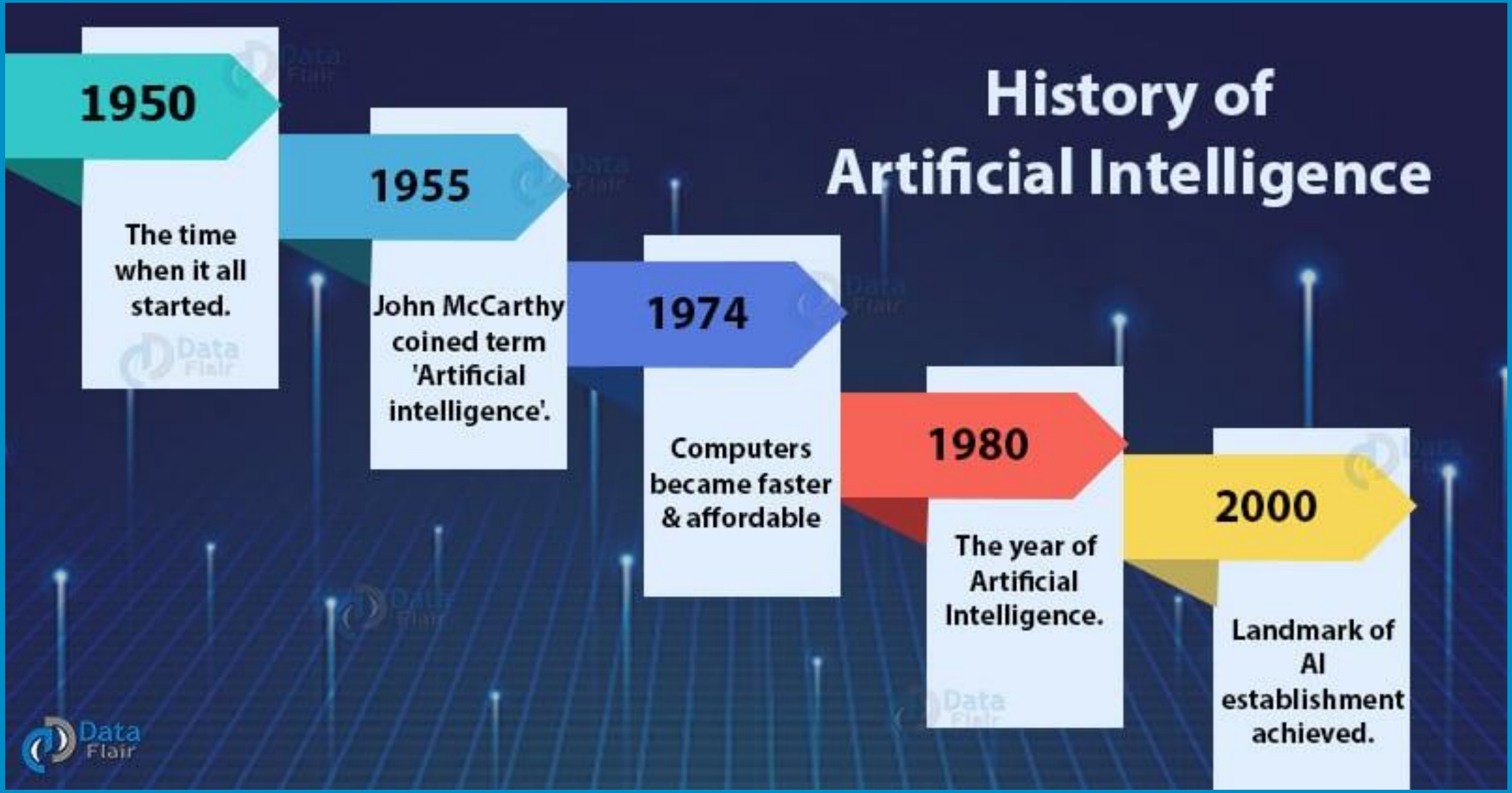
An agent is intelligent when:

1. its actions are appropriate for its circumstances and its goals
2. it is flexible to changing environments and changing goals
3. it learns from experience, and
4. it makes appropriate choices given its perceptual and computational limitations.

AI prehistory

Philosophy	logic, methods of reasoning mind as physical system
Mathematics	foundations of learning, language, rationality formal representation and proof algorithms, computation, (un)decidability, (in)tractability
Psychology	probability adaptation phenomena of perception and motor control
Economics	experimental techniques (psychophysics, etc.)
Linguistics	formal theory of rational decisions knowledge representation grammar
Neuroscience	plastic physical substrate for mental activity
Control theory	homeostatic systems, stability simple optimal agent designs

History of AI



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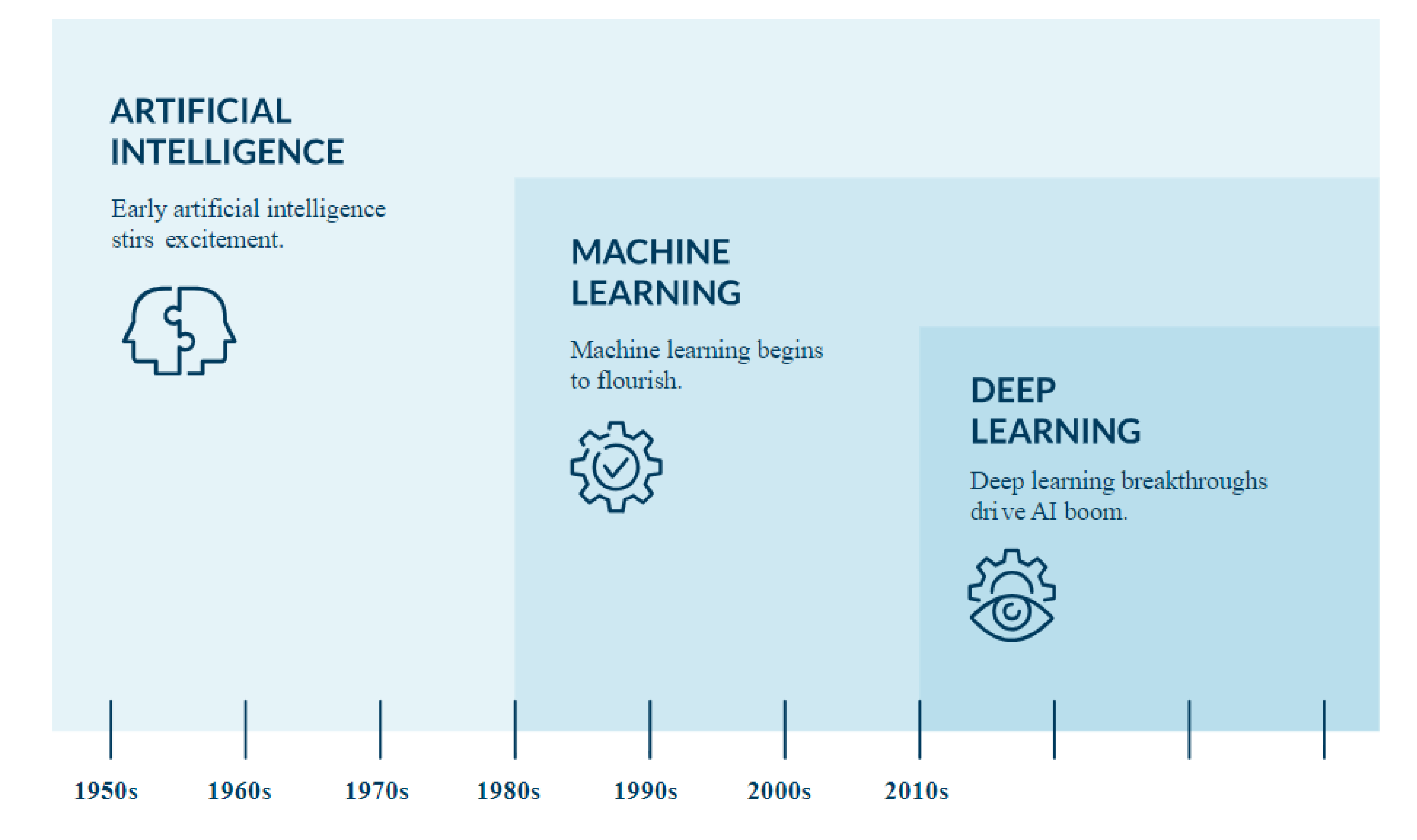
Artificial intelligence, machine learning and deep learning



Artificial intelligence, machine learning and deep learning (Cont’d)

- Artificial intelligence (AI) encompasses the development of "intelligent" machines through programming, which includes everyday items like smartphones, marketing software, chatbots, and virtual assistants.

- Machine learning (ML) involves machines and systems learning from data and algorithms. While often used interchangeably with AI, ML is actually a subset branch of AI.

- Deep learning (DL) extends machine learning (ML) to larger datasets, utilizing multi-layered neural networks to achieve high task accuracy.

- Video: https://youtu.be/4RixMPF4xis?si=Z6Evtji3PUmvR89c

State of the art

Which of the following can be done at present?

1. Play a decent game of table tennis ✓
2. Drive safely along a curving mountain road ✓
3. Drive safely in Cairo ✗
4. Buy a week's worth of groceries on the web ✓
5. Buy a week's worth of groceries at Berkeley Bowl ✗
6. Play a decent game of bridge ✓
7. Discover and prove a new mathematical theorem ✓
8. Design and execute a research program in molecular biology ✓
9. Write an intentionally funny story ✗
10. Give competent legal advice in a specialized area of law ✓
11. Translate spoken English into spoken Swedish in real time ✓
12. Perform a complex surgical operation ✓
13. Unload any dishwasher and put everything away ✗
14. Converse successfully with another person for an hour ??

Risks and Benefits of AI

- “First solve AI, then use AI to solve everything else.” Demis Hassabis, CEO of Google DeepMind

Benefits:

- Decrease repetitive work
- Increase production of goods and services
- Accelerate scientific research (disease cures, climate change and resource shortages solutions)

Risks:

- Lethal autonomous weapons
- Surveillance and persuasion
- Biased decision making
- Impact on employment
- Safety-critical applications
- Cybersecurity threats

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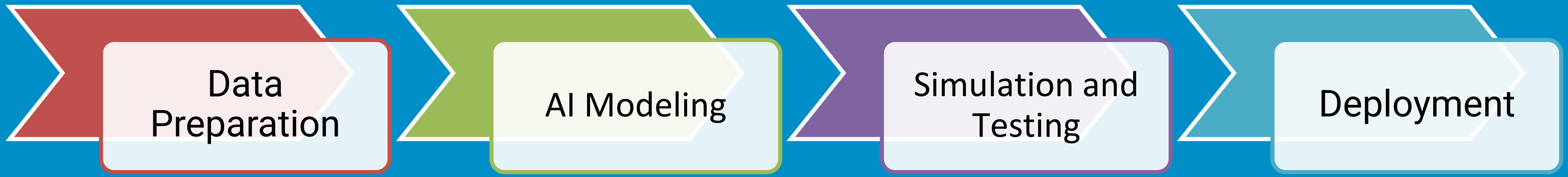
Key Components to an AI Workflow

- Success with AI requires more than training an AI model, especially in AI-driven systems that make decisions and take action.
- A solid AI workflow involves preparing the data, creating a model, designing the system on which the model will run, and deploying to hardware or enterprise systems.

The steps in the AI workflow



Data Preparation

- Taking raw data and making it useful for an accurate, efficient, and meaningful model is a critical step. In fact, it represents most of your AI effort.

Data preparation requires domain expertise

- Such as experience in speech and audio signals, navigation and sensor fusion, image and video processing, and radar and lidar.
- Engineers in these fields are best suited to determine what the critical features of the data are, which are unimportant, and what rare events to consider.
- AI also involves prodigious amounts of data…

Labeling data and images is tedious

- Yet labeling data and images is tedious and time-consuming.
- Sometimes, you don't have enough data, especially for safety-critical systems. Generating accurate synthetic data can improve your data sets.
- In both cases, automation is critical to meeting deadlines.

AI Modeling

- Key factors for success in modeling AI systems are to:
  - Start with a complete set of algorithms and prebuilt models for machine learning, deep learning, reinforcement learning, and other AI techniques
  - Use apps for productive design and analysis
  - Work in an open ecosystem where AI tools like MATLAB®, PyTorch, and TensorFlow™ can be used together
  - Manage compute complexity with GPU acceleration and scaling to parallel and cloud servers and on-premise data centers

System Design

- AI models exist within a complete system.
- In automated driving systems, AI for perception must integrate with algorithms for localization and path planning and controls for braking, acceleration, and turning.
- Complex, AI-driven systems like predictive maintenance for wind farms and autopilot controls for today’s aircraft these require integration and simulation.

Deployment

- AI models need to be deployed to CPUs, GPUs, and/or FPGAs in your final product, whether part of an embedded or edge device, enterprise system, or cloud.
- AI models running on the embedded or edge device provide the quick results needed in the field, while AI models running in enterprise systems and the cloud provide results from data collected across many devices.
- Frequently, AI models are deployed to a combination of these systems.

The deployment process is accelerated

- When you generate code from your models and target your devices.
- Using code generation optimization techniques and hardware-optimized libraries, you can tune the code to fit the low power profile required by embedded and edge devices or the high-performance needs of enterprise systems and the cloud.

Risks and Benefits of AI

- Development of an artificial superintelligence that surpasses human intelligence may pose a significant risk
- Analogous to the "Gorilla problem"
- Humans and gorillas evolved from the same species, but humans have more control than other primates.
- Thus, we should design AI systems in such a way that they do not end up taking control in the way that Turing suggests they might.

What Is Ethics?

- The terms “ethics” and “morality” are often taken as synonyms.
- Sometimes they are distinguished, however, in the sense that morality refers to a complex set of rules, values and norms that determine or are supposed to determine people’s actions, whereas ethics refers to the theory of morality.
- It could also be said that ethics is concerned more with principles, general judgements and norms than with subjective or personal judgements and values.

What Is Ethics? (Cont’d)

- Etymologically, the word ethics goes back to the ancient Greek “ethos”.
- This originally referred to a place of dwelling, location, but also habit, custom, convention.
- It was Cicero who translated the Greek term into Latin with “mores” (ethos, customs)

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Descriptive Ethics

- Most people, when thinking of ethics, have normative ethics in mind as described below.
- Like ethnology, moral psychology or experimental economics, descriptive ethics deals with the description and explanation of normative systems.
- Experimental results exhibit certain features of moral intuitions of people:
  – Studies using the “ultimatum game” show that many people have certain intuitions about fairness and are willing to sacrifice profits for these intuitions (Güth et al. 1982).

Normative Ethics

- Ethics can be defined as the analysis of human actions from the perspective of “good” and “evil,” or of “morally correct” and “morally wrong.”
- If ethics categorizes actions and norms as morally correct or wrong, one then speaks of normative or prescriptive ethics.
- An example of a norm is that the action of stealing is morally wrong. Normative ethics is usually not regarded as a matter of subjectivity but of general validity. Stealing is wrong for everybody.
- Different types of normative ethics make judgments about actions on the basis of different considerations.
- The most important distinction usually made here is between two types of theories: deontological and consequentialist ethics.

Deontological Ethics

- Deontological ethics is characterized by the fact that it evaluates the ethical correctness of actions on the basis of characteristics that affect the action itself. Such a feature, for example, maybe the intention with which an action is performed or the compatibility with a particular formal principle. The consequences of an action may be considered in addition, but do not form the exclusive basis of the judgment.
- The term deontology or deontological ethics derives from the Greek "deon", which essentially means duty or obligation. Deontology can thus be translated as duty ethics.

A practical example of deontological ethics

- Since the 2000s large and medium-sized companies have increasingly tried to project a social or environmentally friendly image through certain marketing and PR measures. Often, as part of these measures, companies donate sizeable sums to combat certain social ills, improve their environmental footprint, or work with NGOs to more effectively monitor the conditions of production among suppliers. Nevertheless, many citizens refuse to positively assess this commitment of companies as ethically genuine. The public discussion sometimes ridicules such programs of Corporate Social Responsibility (CSR). Critics argue that in these cases companies are not really concerned with rectifying grievances, but only with polishing up their own image and ultimately maximizing their bottom line, albeit in a more sophisticated way. Regardless of whether the CSR projects in question contribute to improving some of the (environmental or social) issues, critics are more concerned with the companies motivations than with their action or the results. The companies motivations being the key deontological element for this argument.

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Consequentialist Ethics

- Consequentialism is another important ethical theory.
- Consequentialist theories determine the ethical correctness of an action or a norm solely on the basis of their (foreseeable) consequences.
- The difference between consequentialism and deontological ethics can be seen in the previously used example. From the perspective of consequentialism, the motives of a company to invest in CSR play no role. For this ethical evaluation of a company's CSR program, the only decisive considerations relate to the impact on society, wildlife, nature, or maybe social harmony. As long as a CSR program promotes certain values or, more generally, helps to solve certain social problems, the program can be considered ethical.
- This also applies if a particular CSR program was merely motivated by the desire to improve the image of a company or increase sales.

Virtue Ethics

- The concept of virtue ethics mainly goes back to the Greek philosophers Plato who developed the concept of the cardinal virtues (wisdom, justice, fortitude, and temperance), and Aristotle, who expanded the catalogue into eleven moral virtues and even added intellectual virtues (like Sophia=theoretical wisdom).
- The classical view on virtues held that acting on their basis was equally good for the person acting and for the persons affected by their actions. Whether this is still the case in modern differentiated societies is controversial.

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Meta-ethics

- If ethics can be regarded as the theory of morality, meta-ethics is the theory of (normative) ethics. Meta-ethics is concerned, in particular, with matters of existence (ontology), meaning (semantics) and knowledge (epistemology). Moral ontology is an account of what features of the world have moral significance or worth.
- Moral semantics is an account of the meaning of moral terms such as right, wrong, good, bad and ought to name the most prominent. Moral epistemology is an account of how we can know moral truth.

Applied Ethics

- Normative and meta-ethics are usually distinguished from applied ethics. Applied ethics refers to more concrete fields where ethical judgments are made, for example in the areas of medicine (medical ethics), biotechnology (bioethics), or business (business ethics). In this sense, general normative considerations can be distinguished from more applied ones. However, the relation between the two should not be seen as unidirectional, in the sense that general ("armchair") considerations come first and are later applied to the real world. Rather, the direction can be both ways, with special conditions of an area in question bearing on general questions of ethics.

Applied Ethics - Example

- The general ethical principle of solidarity might mean different things under different circumstances. In a small group, it might imply directly sharing certain goods with your friends and family. In a larger group or in an entire society, however, it might imply quite different measures, such as competing fairly with each other.

Machine Ethics

- Machine ethics attempts to answer the question: what would it take to build an ethical AI that could make moral decisions? The main difference between humans making moral decisions and machines making moral decisions is that machines do not have “phenomenology” or “feelings” in the same way as humans do (Moor 2006).

- They do not have “moral intuition” or “acculturation” either. Machines can process data that represents feelings (Sloman and Croucher 1981), however, no one, as yet, supposes that computers can actually feel and be conscious like people. Life- like robots have been developed (e.g. Hanson Robotics Sophia—see Fig.3.3) but these robots do not possess phenomenal consciousness or actual feelings of pleasure or pain. In fact, many argue that the robot Sophia represents more of a corporate publicity stunt than a technological achievement and, as such, represents how the mystique around robots and artificial intelligence can be harnessed for attention. In this section we discuss how to design an AI that is capable of making moral decisions. Technical and philosophical elements are presented. Yet we should note that the goal of creating machines that make moral decisions is not without detractors (van Wynsberghe and Robbins 2019). Van Wynsberghe and Robbins note that outside of intellectual curiosity, roboticists have generally failed to present strong reasons for developing moral robots.

Machine Ethics (Cont'd)

- The philosophical element is a detailed moral theory. It will provide us with an account of what features of the world have moral significance and a decision procedure that enables us to decide what acts are right and wrong in a given situation.

Machine Ethics (Cont’d)

- For philosophical convenience, we assume our AI is embedded in a humanoid robot and can act in much the same way as a human.
- This is a large assumption but for the moment we are embarking on a philosophical thought experiment rather than an engineering project.

Machine Ethics Examples

- The process for an ethical AI embedded in a robot starts with sensor input. We assume sensor input can be converted into symbols and that these symbols are input into a moral cognition portion of the robot’s control system.
- The moral cognition system must determine how the robot should act. We use the term symbol grounding to refer to the conversion of raw sensor data to symbols. Symbols are used to represent objects and events, properties of objects and events, and relations between objects and events.

Reasoning in an AI

- Involves the use of logic. Logic is truth-preserving inference. The most famous example of logical deduction comes from Aristotle. From two premises, “Socrates is a man” and “all men are mortal” the conclusion
- “Socrates is mortal” can be proved. With the right logical rules, the premises we may need to deduce action will be based on symbols sensed in the environment by the robot.

Reasoning in an AI (Cont’d)

- To illustrate, we can assume that our robot is tasked with issuing tickets to speeding cars. We can also assume also that the minimal input the system needs to issue a ticket is the symbol representing the vehicle (e.g. the license plate number) and a symbol representing whether or not the vehicle was speeding (Speeding or NOT Speeding). A logical rule of of inference can be stated as “If driver X is speeding then the robot U is obligated to issue a ticket to driver X.” In much the same was as we can deduce “Socrates is a mortal” from two premises, we can derive a conclusion such as “the robot U is obligated to issue ticket” from the rule of inference above and a statement like “the driver of car X is speeding.”

Moral Diversity and Testing

- One of the main challenges for machine ethics is the lack of agreement as to the nature of a correct moral theory. This is a fundamental problem for machine ethics. How do we implement moral competence in AIs and robots if we have no moral theory to inform our design?
- One could design ethical test cases that an AI has to pass. Ideally we would create many test cases. Moral competence can be defined with respect to the ability to pass these test cases. In theory, as an agent or robot goes through iterative cycles of responding to new test cases its moral competence would expand. In so doing, one might gain insights into moral theory.

Moral Diversity and Testing (Cont’d)

- Testing and even certifying if an AI is fair and ethical is currently an important area of research. The Institute of Electrical and Electronics Engineers (IEEE) announced a Standards Project that addresses algorithmic bias considerations in 2017. Toolkits have been created that help developers to test if their software does have a bias, such as the AI Fairness 360 Open Source Toolkit,1 audit-AI.2 Some companies offer services to test the bias of algorithms, such as O’Neil Risk Consulting and Algorithmic Auditing,3 and even big companies like Facebook are working on Fairness Flow, a tool to test biases. Keeping in mind that this is an area of ongoing inquiry, it should be noted that some researchers are pessimistic about the prospects for machine morality. Moreover, a number of research groups have developed or are developing codes of ethics for robotics engineers (Ingram et al. 2010) and the human-robot interaction profession (Riek and Howard 2014).

Case Study 1

- In the United States, several jurisdictions have implemented AI-powered risk
- Assessment tools to predict a defendant's likelihood of reoffending, and to inform
- Decisions about bail, sentencing, and parole.
- This incident raises several questions about responsibility and liability for AI systems, including:

Case Study 1 (Cont'd)

- Who is responsible for the biases in the AI algorithm? The developers of the AI system or the jurisdiction using it?
- How should jurisdictions ensure that their AI systems are not biased against certain groups of people?
- What ethical considerations were involved in the development and use of the AI algorithm?
- What steps should be taken to mitigate the impacts of biased AI systems on marginalized communities?
- How should AI systems be regulated to ensure that they are used in a fair and just manner?

Case Study 2

- China has been implementing a social credit system that uses AI-powered facial recognition to track and score the behavior of its citizens. The system assigns a social credit score to each citizen based on their behavior, such as paying bills on time, participating in community service, or engaging in illegal activities. Citizens with higher scores are rewarded with benefits such as better access to loans, while those with lower scores may face penalties such as travel restrictions or difficulty finding employment.

Case Study 2 (Cont'd)

- This raises important questions about the potential trade-offs between privacy and security.
- On the one hand, facial recognition technology can be used to enhance public safety and prevent crime.
- On the other hand, it also raises concerns about the potential misuse of personal data and the infringement of individual privacy rights.

Discussion

- What are the potential benefits and risks of using facial recognition technology for social credit systems?
- How can the use of facial recognition technology be balanced with individual privacy rights and data protection?
- Should the use of facial recognition technology for social credit systems be regulated? If so, by whom and how?
- What are the ethical considerations involved in using facial recognition technology for social credit systems, and how can they be addressed?
- How can we ensure that the use of facial recognition technology is transparent and accountable and that citizens have a say in how their data is collected and used?

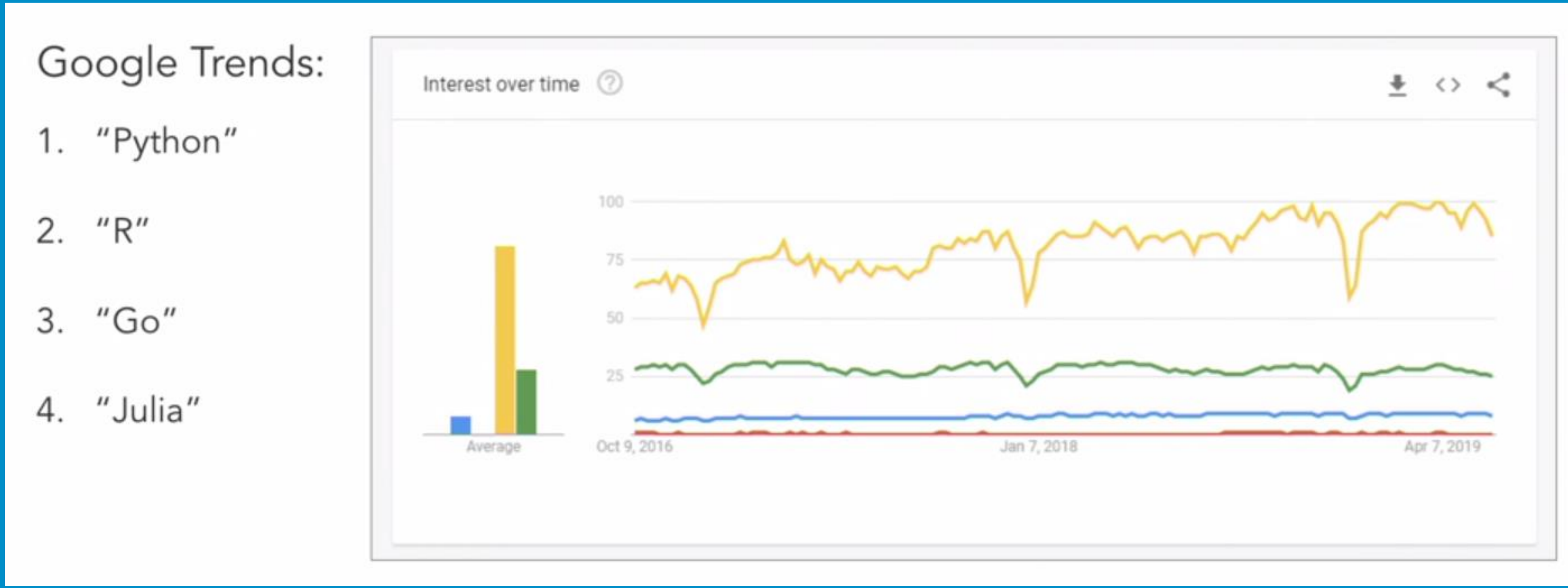
Coding Languages for Data Science

- Python
- R
- Julia
- Go

Python Programming Language

- Python is a high-level, interpreted coding language that is useful for a very wide variety of applications.
  – Easy to learn, human readable
  – Extensive array of well-supported data science libraries
  – Useful in data engineering

Python Is a Popular Language



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Python is useful for:

- Data science, Data analytics, and data engineering
- Useful in both in professional and an academic environment
- Python is an open-source programming language
- Web development
- Application development
- Game development

Main Python Libraries for Data Science

Advanced Data Analysis	Data Visualization	Machine Learning
NumPy	Matplotlib	scikit-learn
SciPy	Seaborn	TensorFlow
pandas		Keras

Python Modes

1. IPython

Python can be run interactively

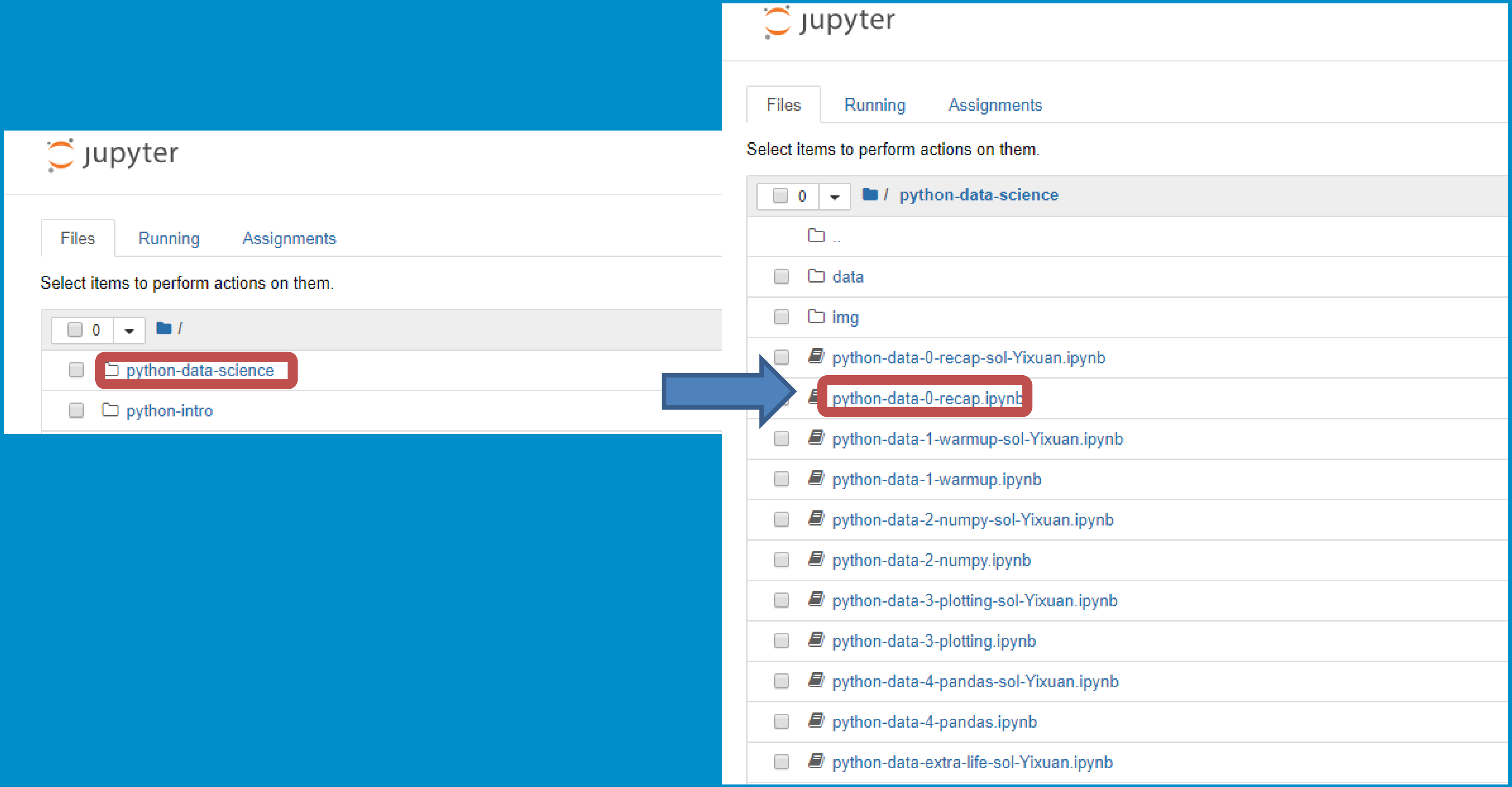
Used extensively in research

2. Python scripts

What if we want to run more than a few lines of code?

Then we must write text files in .py

Starting a notebook



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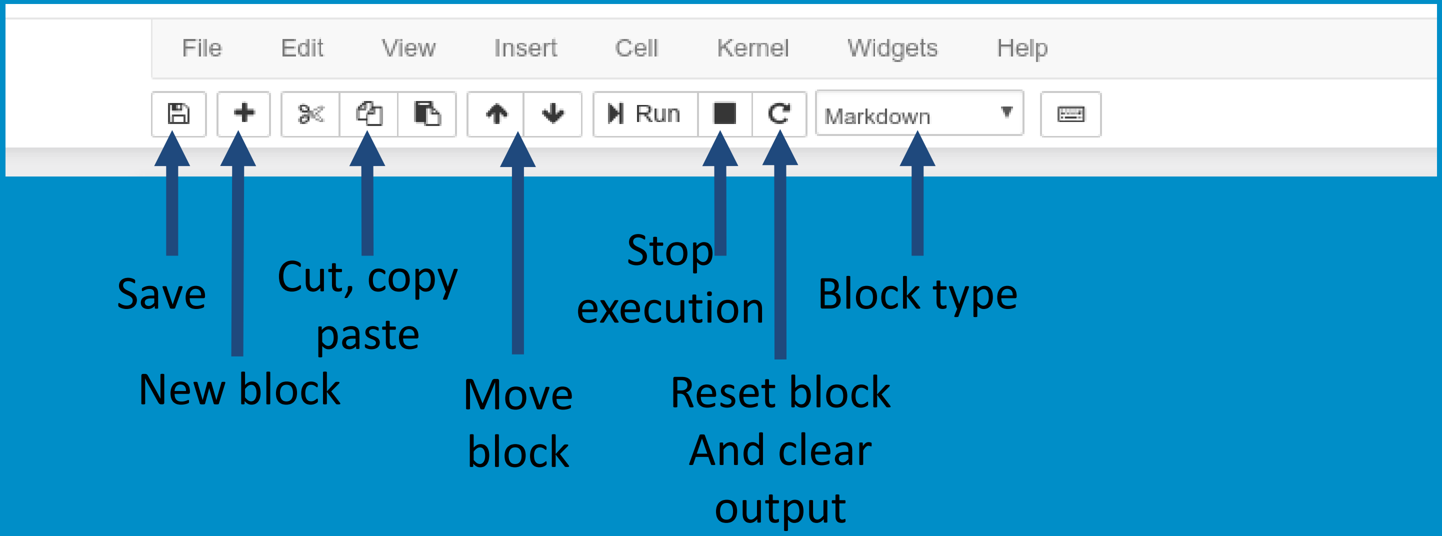
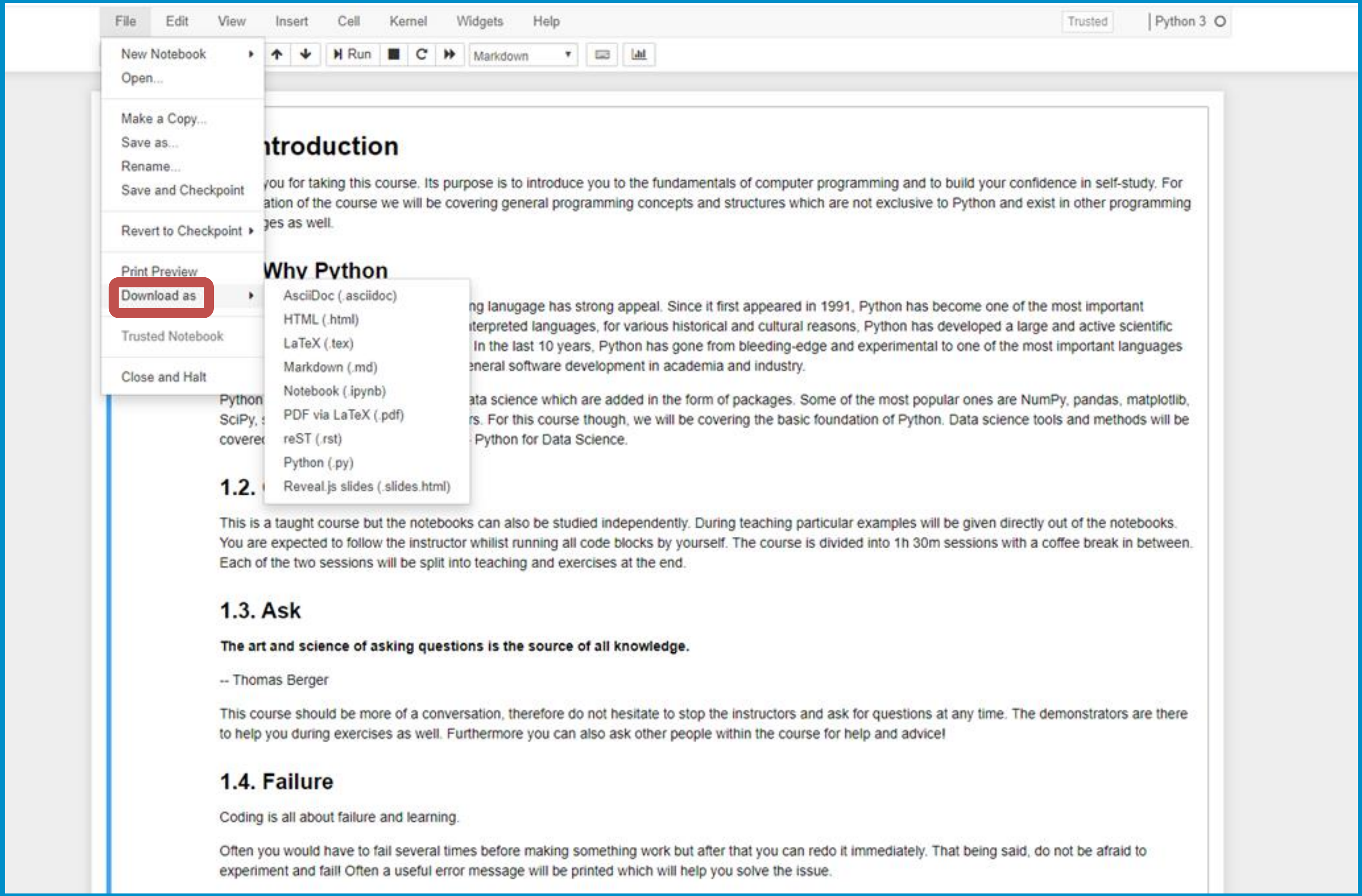
Toolbar


File
Edit
View
Insert
Cell
Kernel
Widgets
Help
Run
Markdown
Save
New block
Cut, copy paste
Move block
Stop execution
Reset block And clear output
Block type

Download files



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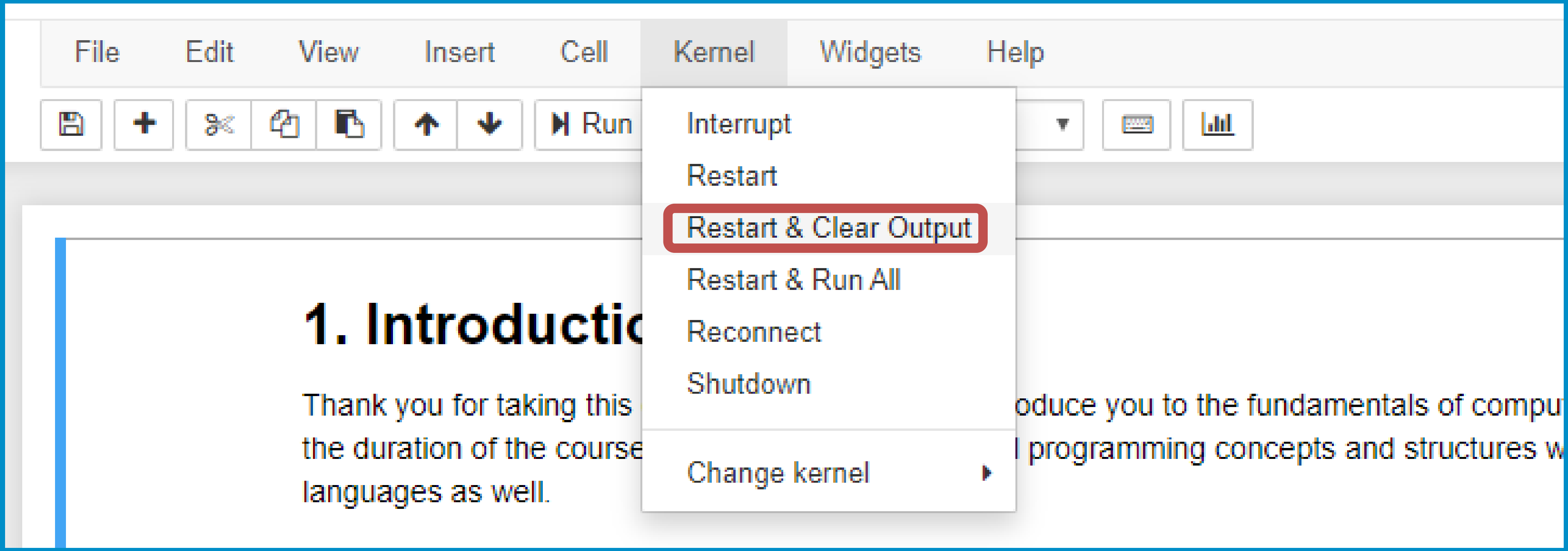
Kernel/Restart & Clear output



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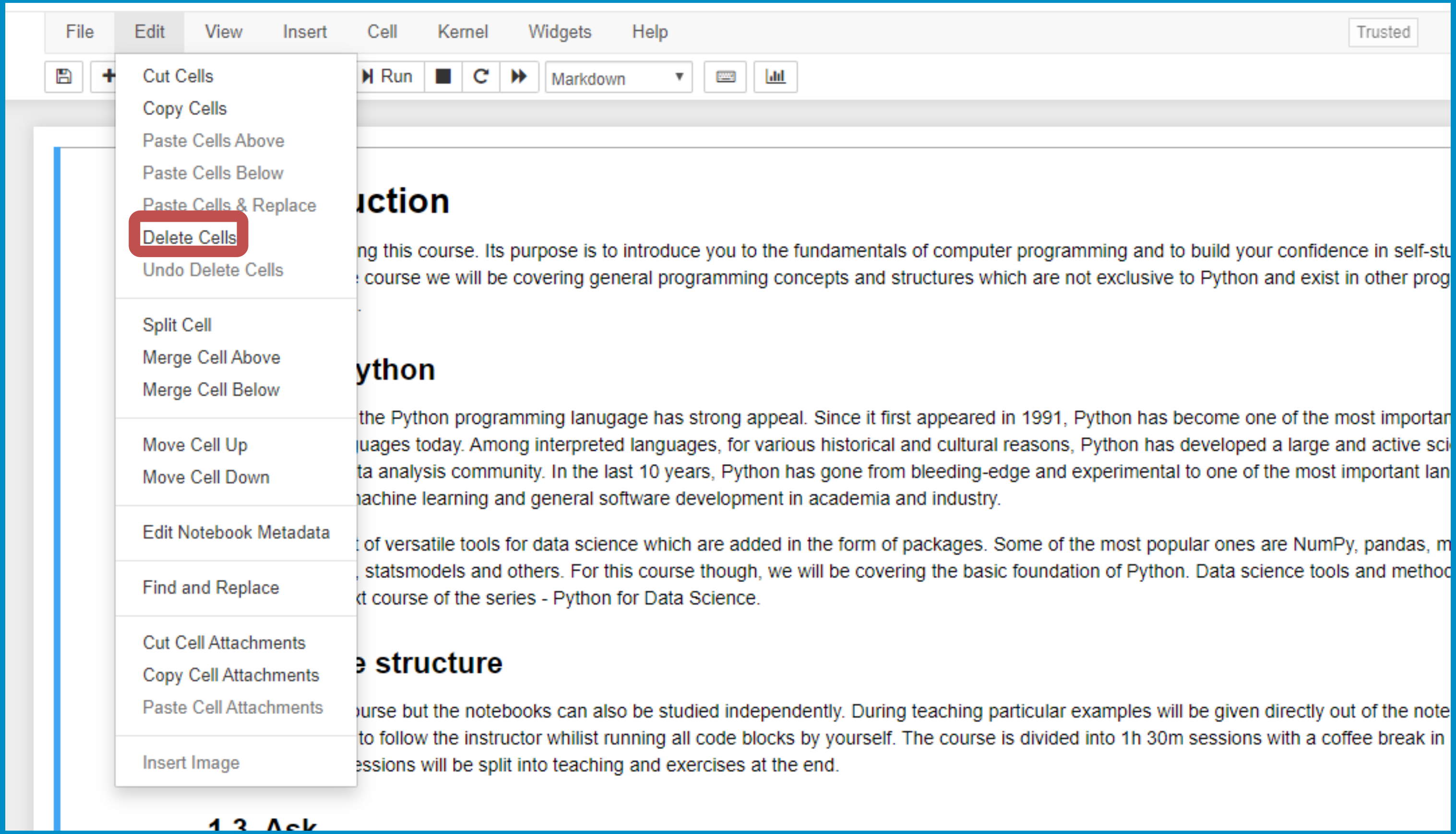
Edit/Delete Cell



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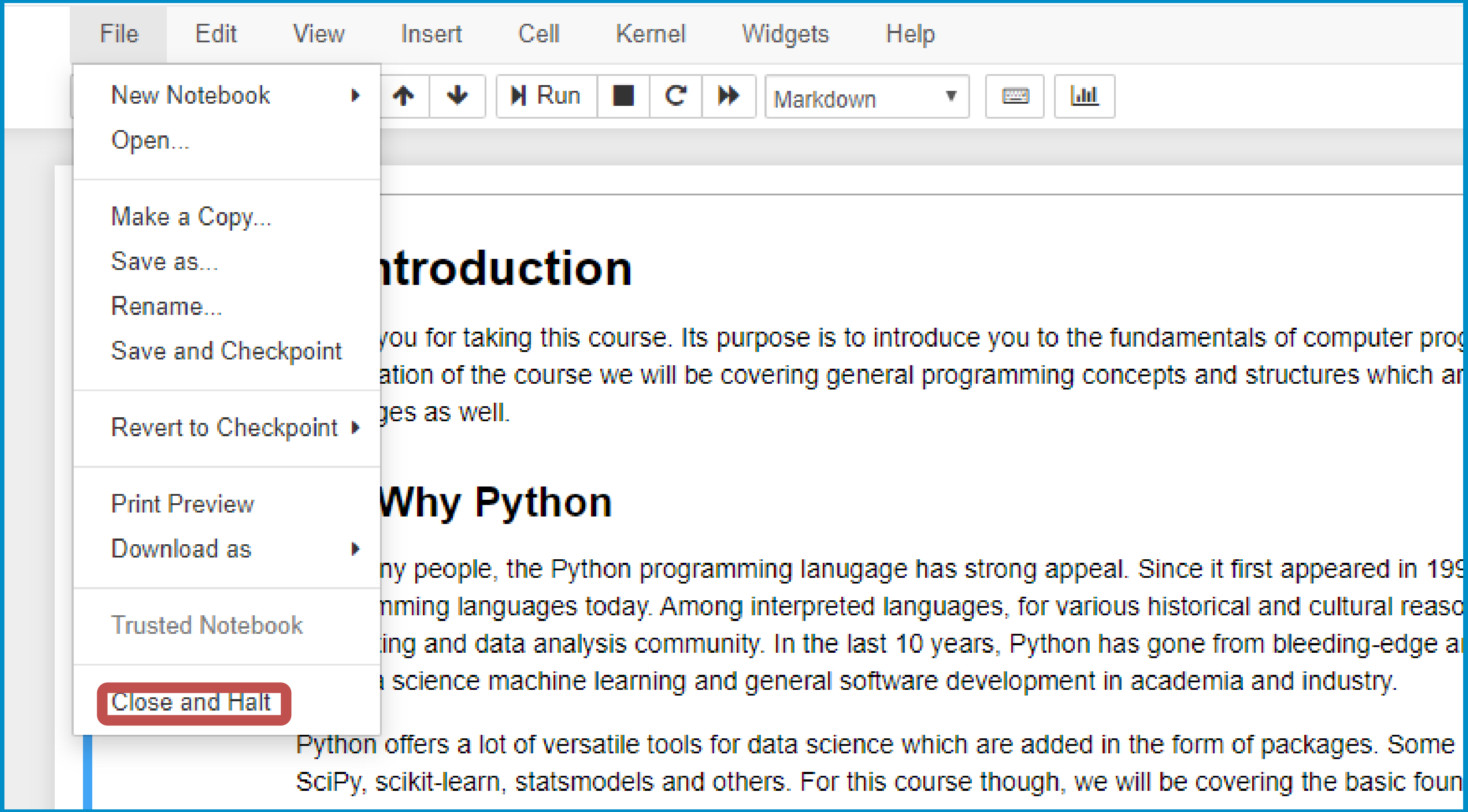
File/ Close & Halt



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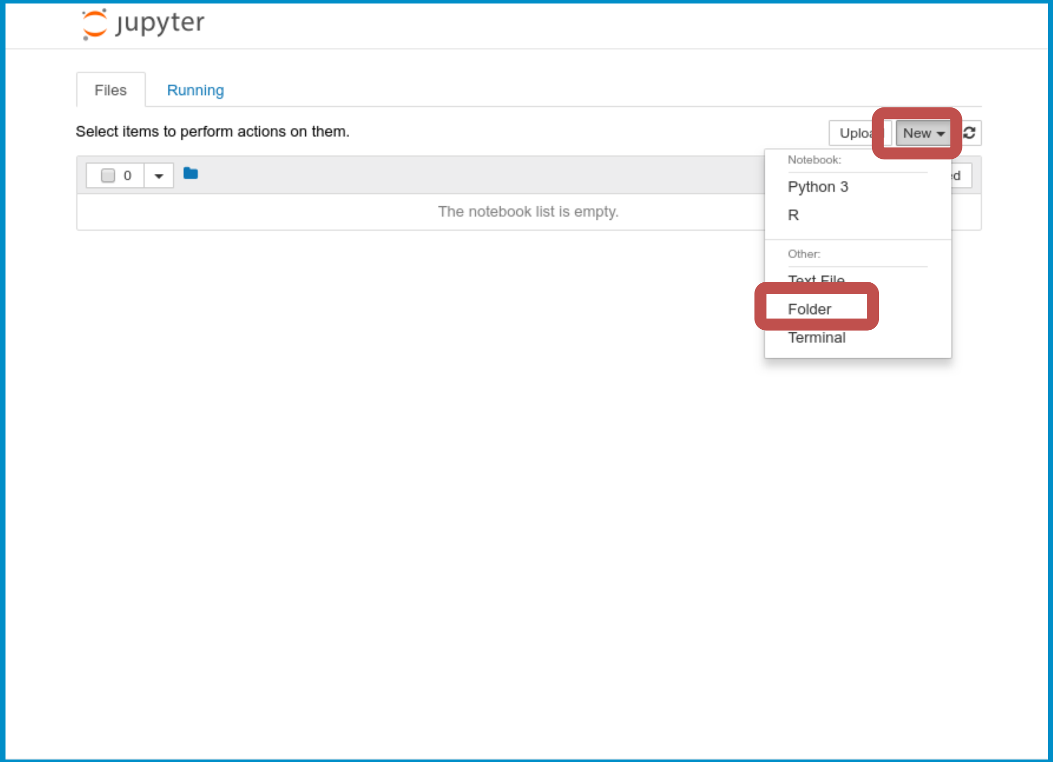
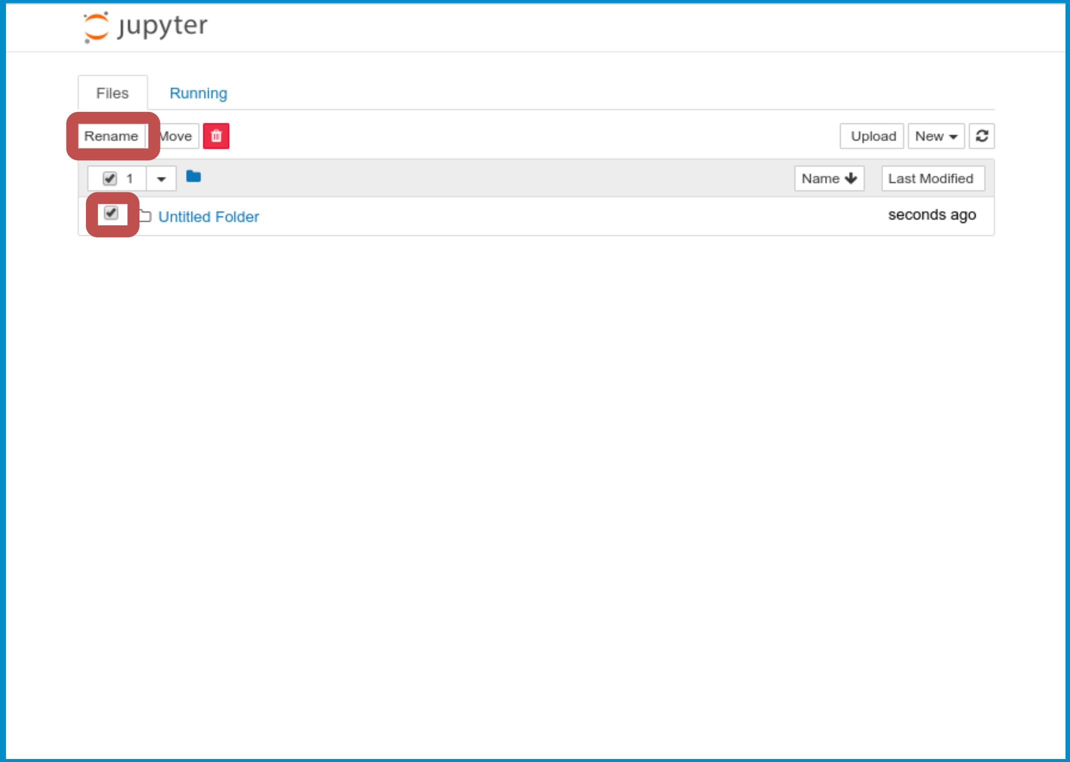
Create and rename folders

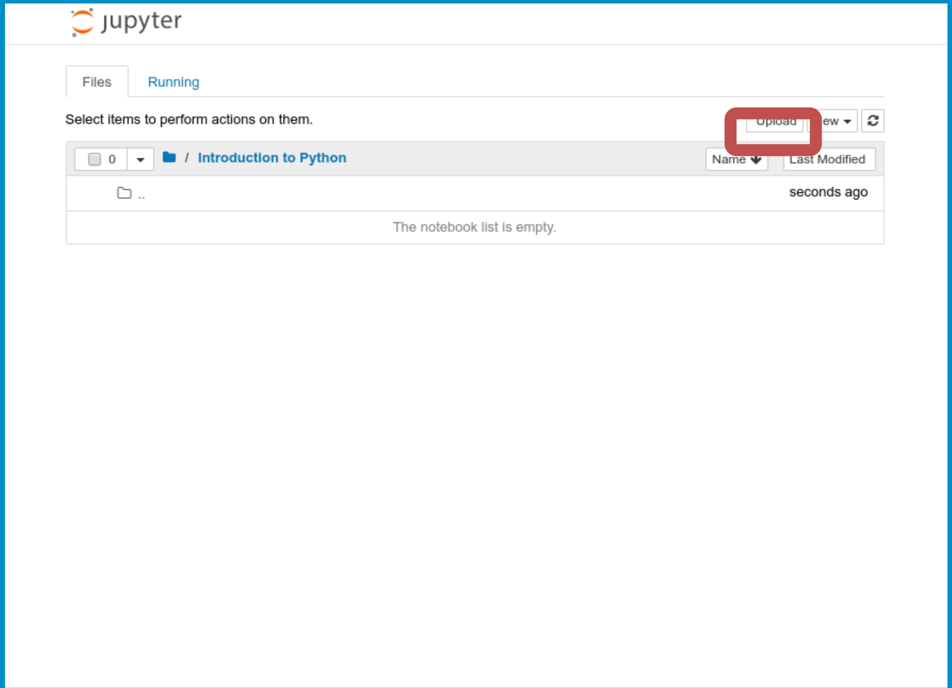
Create a folder

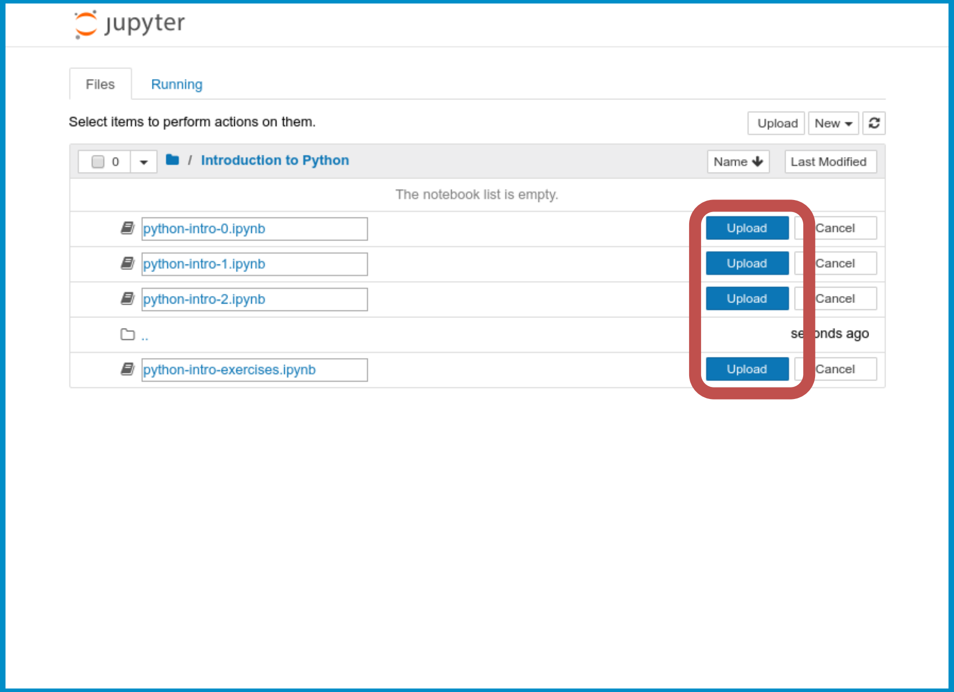


Rename



Upload files





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Running blocks

- By pressing the Run button
- Shift + Enter – runs block
- Alt + Enter – creates a new block