Building Software Systems

Lecture 5.1

Introduction to AI-intensive Systems

SAURABH SRIVASTAVA

ASSISTANT PROFESSOR

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

IIT (ISM) DHANBAD

In this Unit

We will be looking at AI/ML in this unit

- But our focus will not be on Algorithms, we will focus on its usage
- In most cases, we will see AI/ML elements as a “component” of the system being built
- We will see them mostly as “blackboxes” achieving some functionality for us

But unlike other (non-AI/ML) components, there are some issues we need to know

- For instance, these components may not be “deterministic” in nature
- They may produce unreliable or unexpected results at times, and we need a way to handle that
- This unit is about these issues

What is AI?

No “crisp” definition

- There are some “schools of thoughts” though

Thinking Humanly

"The exciting new effort to make computers think ... *machines with minds*, in the full and literal sense." (Haugeland, 1985)

"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (Bellman, 1978)

Thinking Rationally

"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)

"The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)

Acting Humanly

"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)

"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)

Acting Rationally

"Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998)

"AI ...is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Some Definitions for "Artificial Intelligence" [1]

What is AI?

No “crisp” definition

- There are some “schools of thoughts” though

Thinking vs *Acting*

- The *Thinking* schools focus on the process that a system follows to arrive at a decision
- The *Acting* schools are more concerned with the behaviour of a system (irrespective of why they do so)

What is AI?

No “crisp” definition

- There are some “schools of thoughts” though

Thinking vs *Acting*

- The *Thinking* schools focus on the process that a system follows to arrive at a decision
- The *Acting* schools are more concerned with the behaviour of a system (irrespective of why they do so)

Most modern-day AI usually concentrates on building *rational agents*

- A **rational agent** is a system that attempts to produce the best result for the given task at hand or, in case it is not feasible due to some uncertainty, attempts to produce the best possible result

Thinking Humanly

"The exciting new effort to make computers think ... *machines with minds*, in the full and literal sense." (Haugeland, 1985)

"[The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (Bellman, 1978)

Thinking Rationally

"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)

"The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)

Most of the systems we are interested today usually fall in this category

Acting Humanly

"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)

"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)

Acting Rationally

"Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998)

"AI ...is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Some Definitions for "Artificial Intelligence" [1]

What is AI?

No “crisp” definition

- There are some “schools of thoughts” though

Thinking vs *Acting*

- The *Thinking* schools focus on the process that a system follows to arrive at a decision
- The *Acting* schools are more concerned with the behaviour of a system (irrespective of why they do so)

Most modern-day AI usually concentrates on building *rational agents*

- A **rational agent** is a system that attempts to produce the best result for the given task at hand or, in case it is not feasible due to some uncertainty, attempts to produce the best possible result

In any case, it may not always be possible to tag a process or behaviour to fall under the category of “Artificial Intelligence” with utmost confidence

What are AI-intensive Systems?

A “working” definition for an AI component

- A self-contained software component that performs some Artificial Intelligence task

Examples of AI components

- A tool to perform OCR (e.g., Google **Tesseract** [2])
- A library to perform text classification tasks such as sentiment analysis (e.g., Facebook **fastText** [3])
- A service to convert speech to text (e.g., IBM **Watson Speech to Text** [4]) etc.

Most commercial AI components have well defined interfaces to connect them with other components in order to achieve some business goals

- The “other” components may or may not be AI components

We refer to systems which deploy such components as AI-intensive Systems

- Examples: **Facebook** [5], **CamScanner** [6], **Siri** [7] etc.

How are they “different”?

Code vs *Code + Models*

- Along with code, one has to deal with models as well
- Unlike code, models are hard to “fine-tune” with respect to failing test cases

Debugging vs Retraining

- With respect to models, the call to make is – “*shall we rebuild the model with more or better data, or stick to whatever we have now*”
- The options that can be tweaked before retraining cannot be easily mapped to the required change

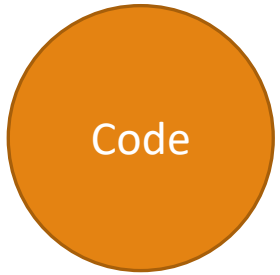
Predictability vs Cascading Uncertainty

- Usually, models operate in the realm of “probabilities”
- It is generally not possible to definitively predict the behaviour of a model over any “unseen” input
- This uncertainty “cascades” and a system must find ways to deal with it

Based on [8]

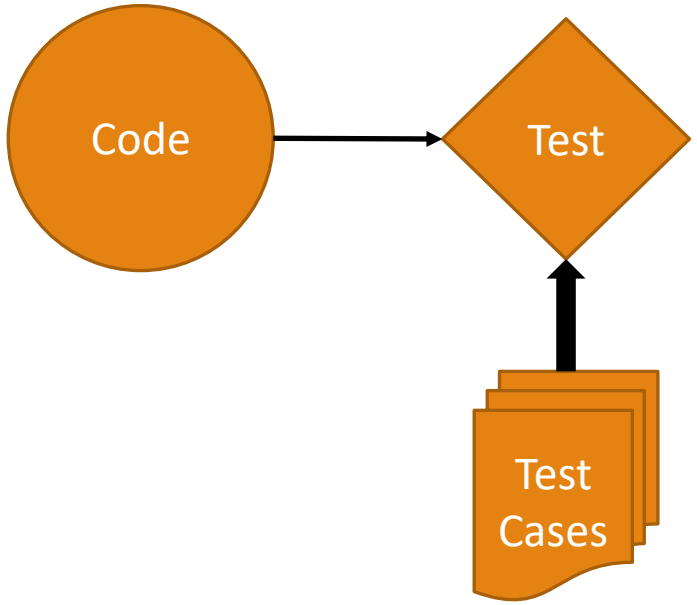
How are they “different”?

“Traditional” approach towards building a system:



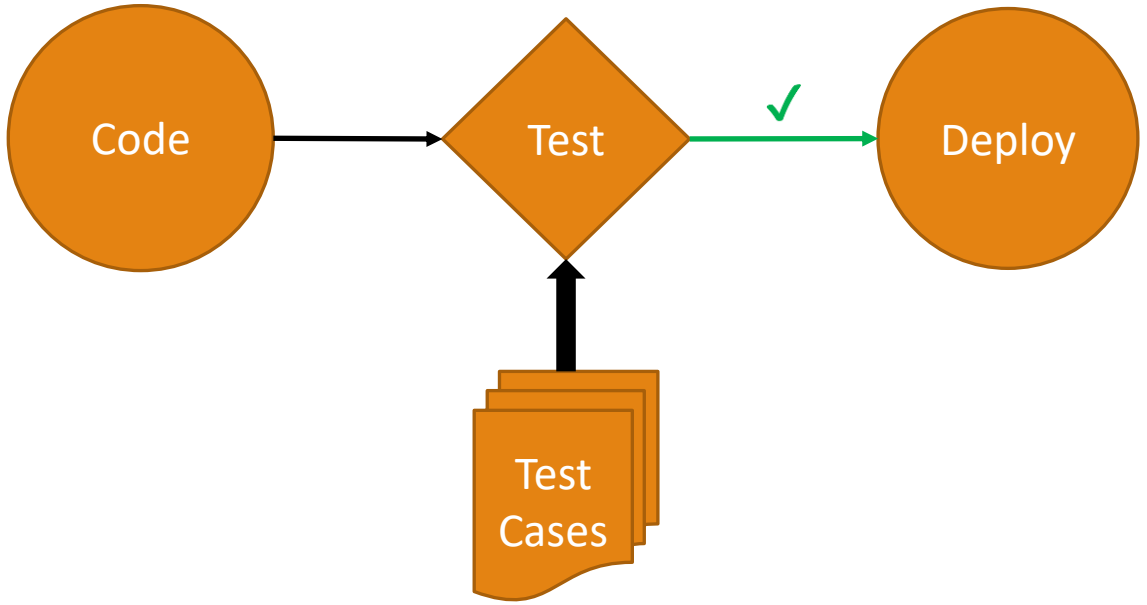
How are they “different”?

“Traditional” approach towards building a system:



How are they “different”?

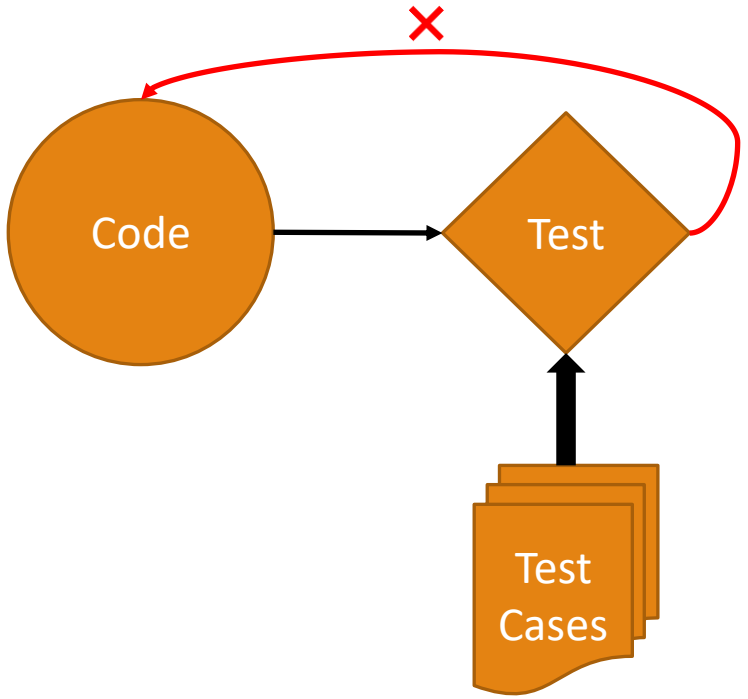
“Traditional” approach towards building a system:



✓ - All Tests Passed

How are they “different”?

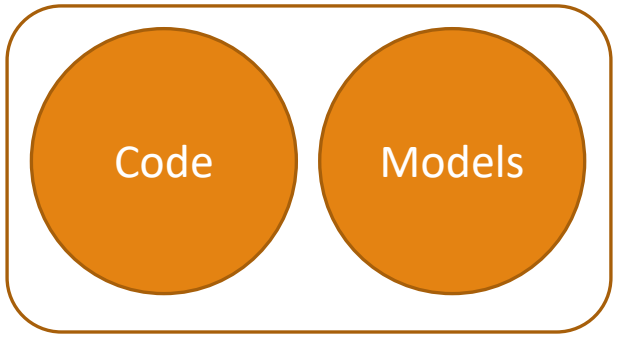
“Traditional” approach towards building a system:



✕ - Some Test(s) Failed

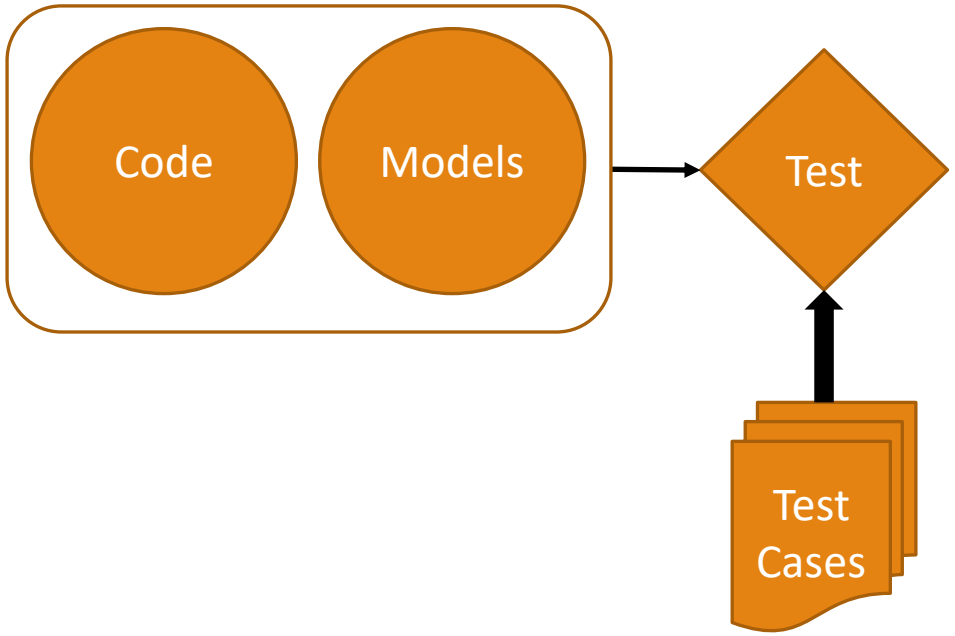
How are they “different”?

Building a system with AI components:



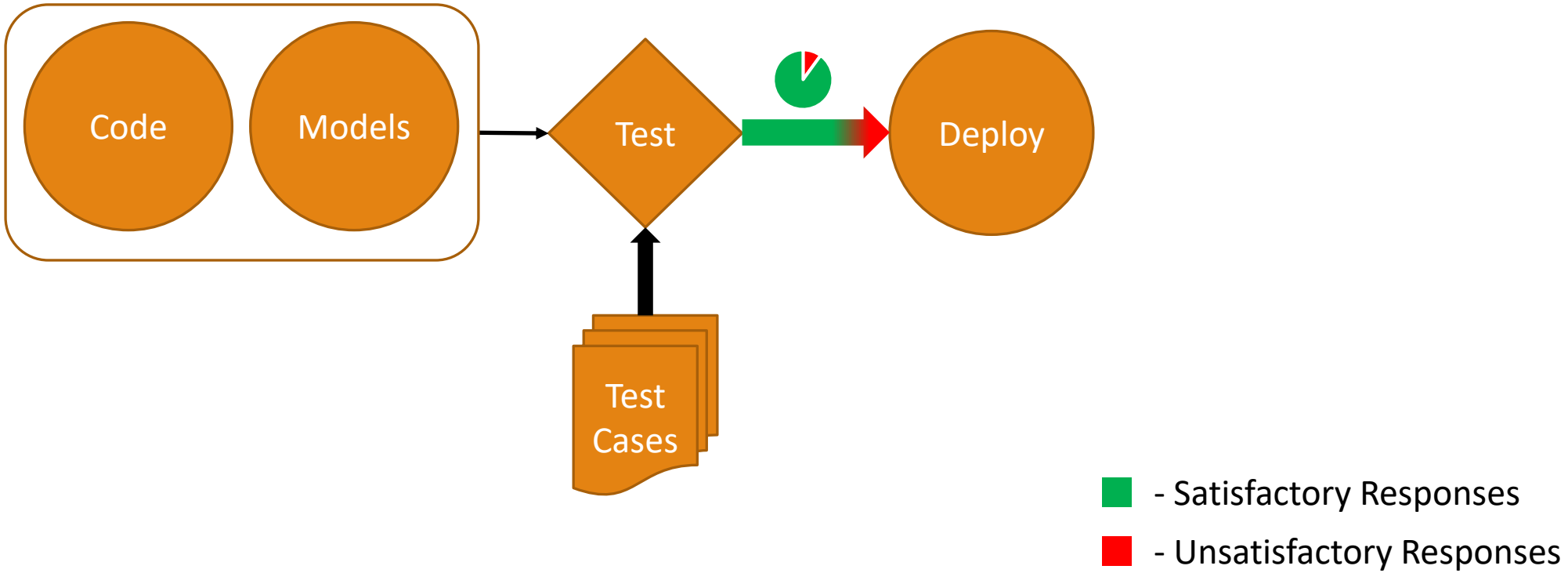
How are they “different”?

Building a system with AI components:



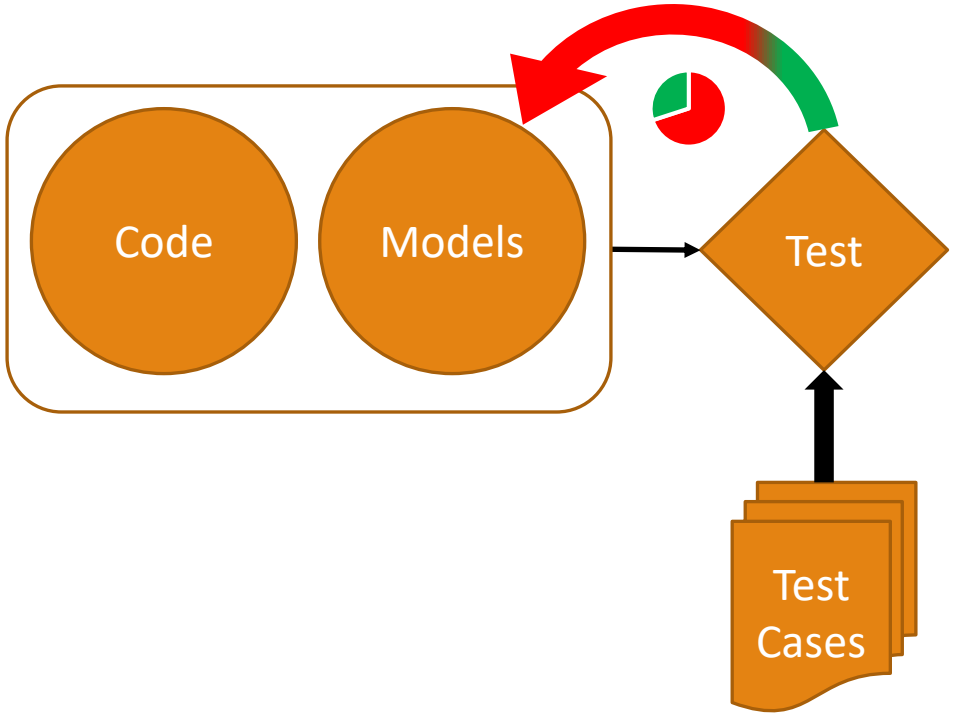
How are they “different”?

Building a system with AI components:



How are they “different”?

Building a system with AI components:



- Satisfactory Responses

- Unsatisfactory Responses

References

[1] Artificial Intelligence: A Modern Approach, 3rd Edition by **Stuart Russell** and **Peter Norvig**, Pearson Education Limited

[2] Tesseract OCR: Optical Character Recognition engine for various Operating Systems, https://opensource.google/projects/tesseract

[3] fastText: Library for learning of word embeddings and text classification, https://fasttext.cc/

[4] Watson Speech to Text: Cloud-native solution for customizable speech recognition, https://www.ibm.com/cloud/watson-speech-to-text

[5] Facebook: Social media website, https://www.facebook.com/

[6] CamScanner: Mobile app that allows iOS and Android devices to be used as image scanners, https://www.camscanner.com/

[7] Siri: A virtual assistant that is part of Apple Inc.'s iOS, iPadOS, watchOS, macOS, and tvOS operating systems, https://www.apple.com/in/siri/

[8] Artificial intelligence in the software engineering workflow - Peter Norvig (Google), https://www.youtube.com/watch?v=mJHvE2JLN3Q