AI-Driven Test Generation
Machines Learning from Human Testers

Dionny Santiago
Test Architect, Ultimate Software

Tariq M. King
Senior Director/Engineering Fellow, Ultimate Software

Peter J. Clarke
Associate Professor, Florida International University

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Agenda

Motivation

AI/Machine Learning

Applying AI to Testing

State of the Art

Breaking into AI

Web Automation

Expensive

Lacks generality

High maintenance

```
@Test
public void successLoginSampleTest()
    product.login.userNameTextBox
        .set("user@test.com");

    product.login.passwordTextBox
        .set("testp@ssword");

    product.login.loginButton.click();
}
```

Sign In

Email

Password

Login failed. Please enter a valid email and password.

Sign In   Forgot your password?

Don't have an account? Register

```
public class LoginPage extends Page {
    public TextBox userNameTextBox;
    public TextBox passwordTextBox;
    public Button loginButton;

    public LoginPage(AutomationInfo automationInfo) {
        userNameTextBox = new TextBox(automationInfo,
            By.cssSelector("input#email"));

        passwordTextBox = new TextBox(automationInfo,
            By.cssSelector("input#password"));

        loginButton = new Button(automationInfo,
            By.cssSelector("button#login"));
    }
}
```
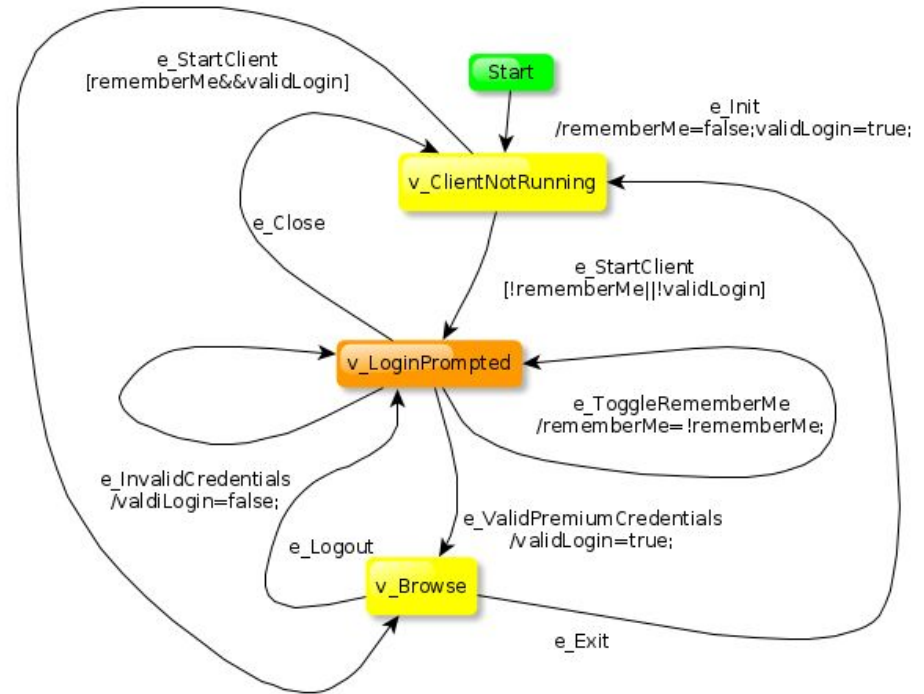
Se

Model-Based Testing

Semi-automated

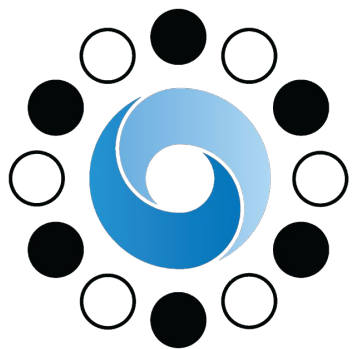Build model, generate tests. Generality?

Model maintenance.

https://graphwalker.github.io/

Machine vs. Human Testing

How do we...

Enable Learning?

Mimic Humans?

Support Generality?

AlphaGo

AUTONOMOUS CAR

Blind Spot Detection

Park Assistance

Rear Collision Warning

Blind Spot Detection

Surround View

Park Assistance

Cross Traffic Alert

Lane Departure Warning

Traffic Sign Recognition

Surround View

Emergency Braking / Pedestrian Detection / Collision Avoidance

Adaptive Cruise Control

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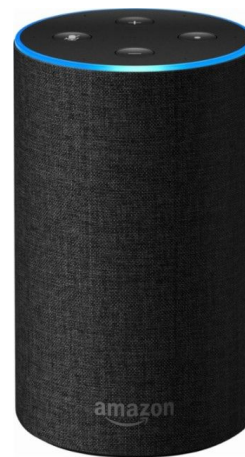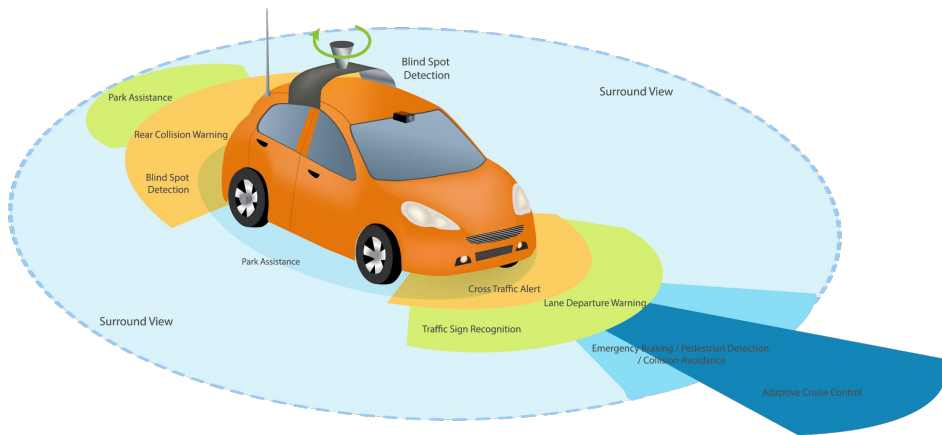
AI and Machine Learning

AI - A branch of CS dealing with simulation of intelligent behavior in computers.

Machine Learning - Science of getting computers to act without being explicitly programmed. Data!
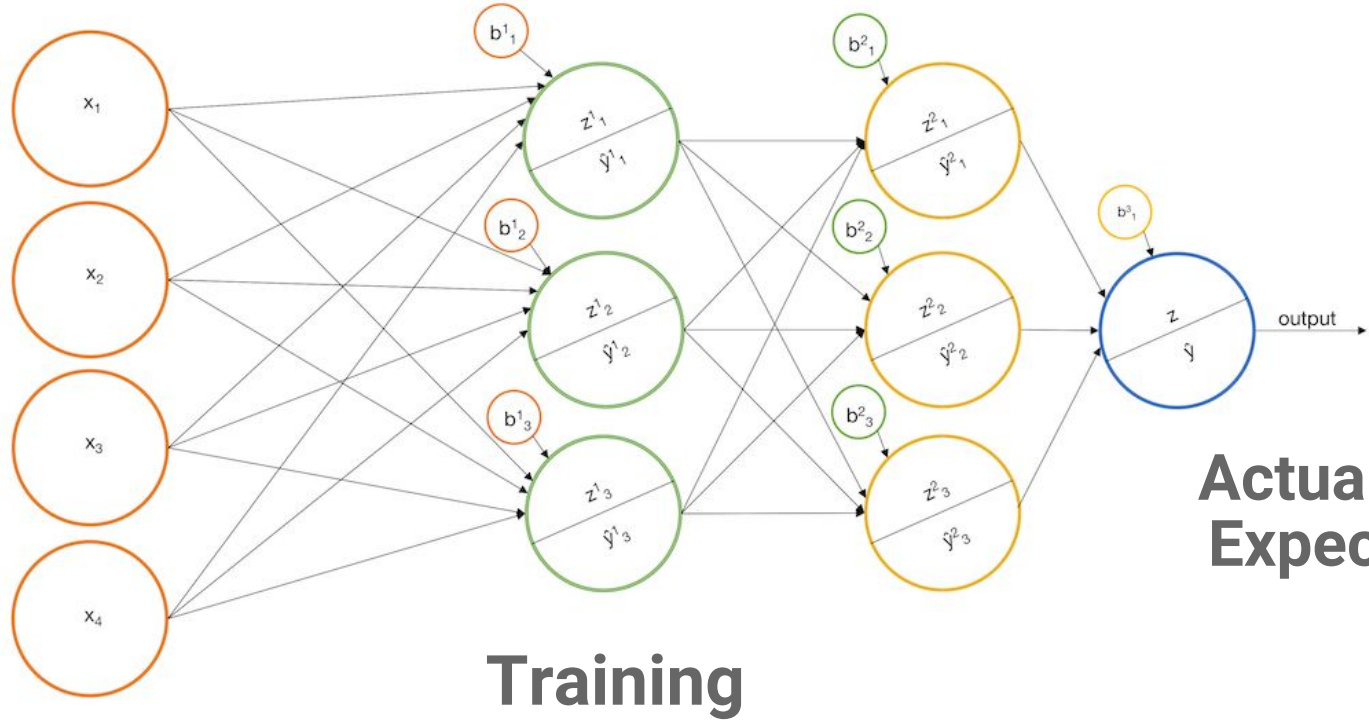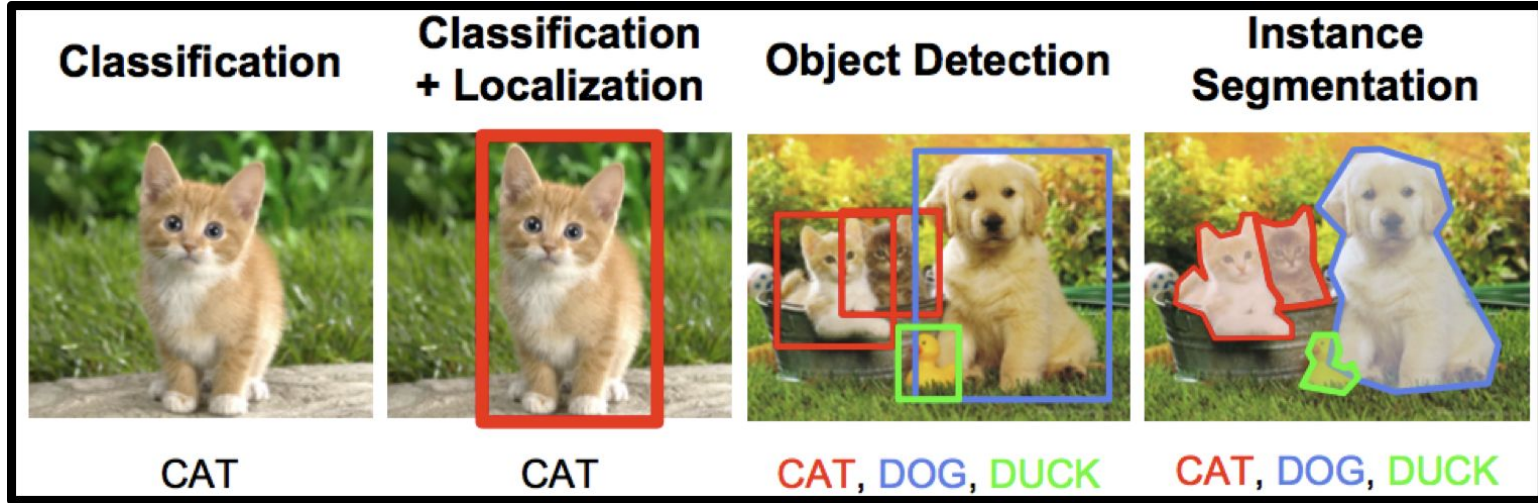
AI and Machine Learning
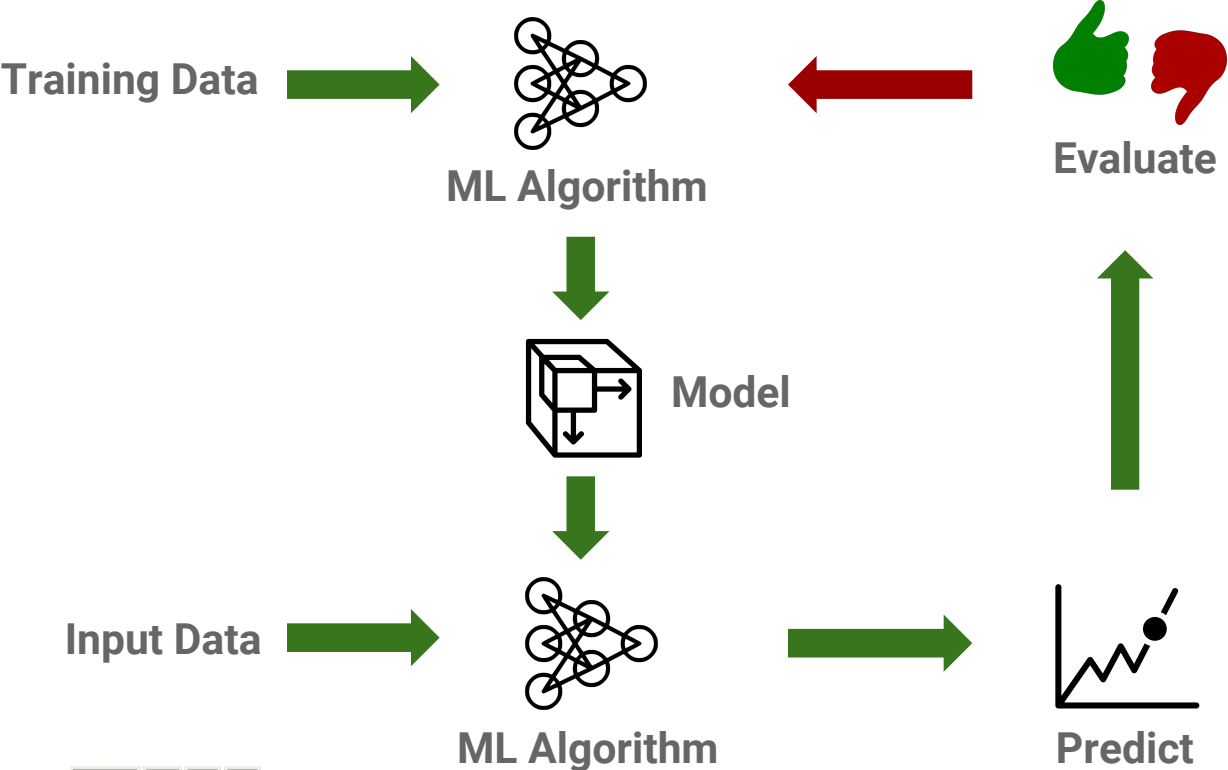
Neural Networks

Features

Propagate

Answer

AI ⬌ Testing

Test Inputs

Training

Actual vs. Expected

output

Applying AI to Testing

Object Recognition

Text Generation
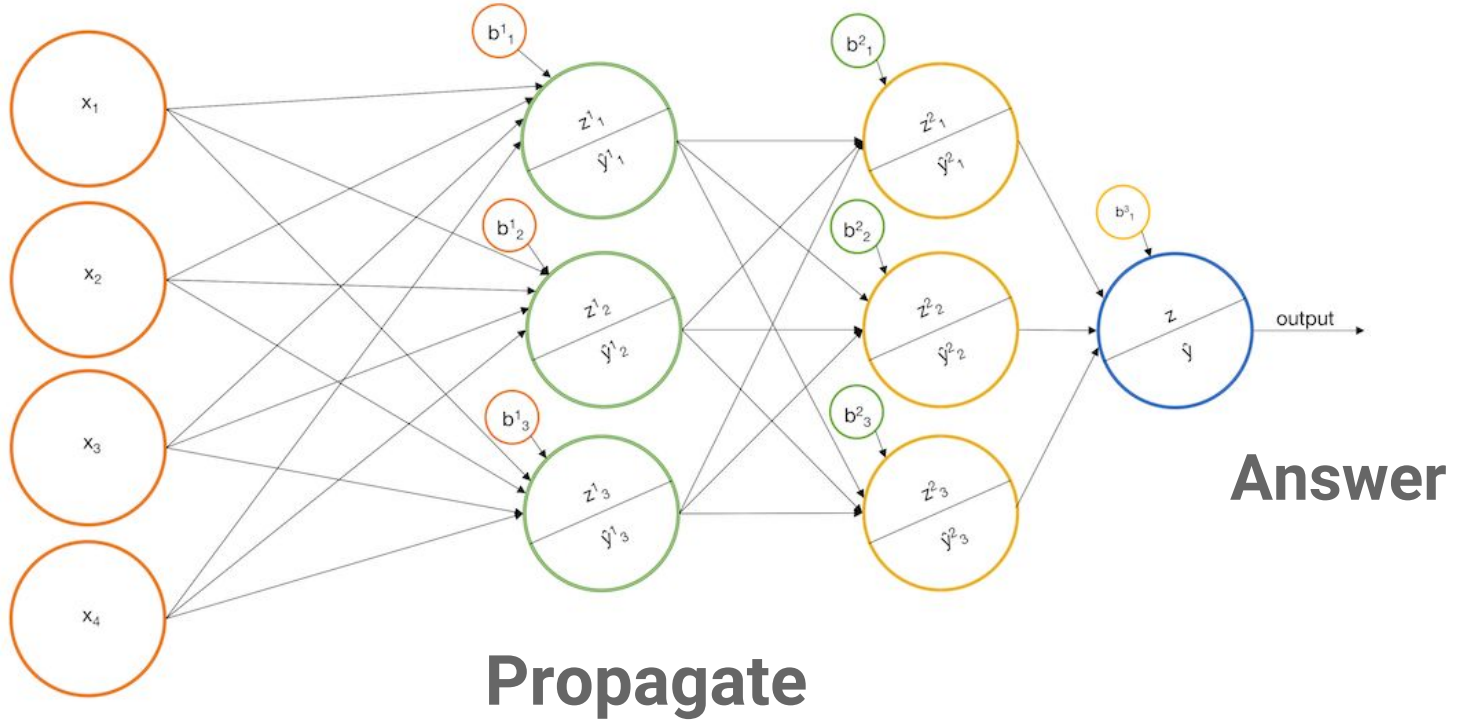
Research: Object Recognition

Different types of problems:

Research: Object Recognition

Image pixels are input into an ML algorithm

28 x 28
784 pixels

Applying: Object Recognition

Recognize webpage components

Steps:

Collect Examples

Label Examples

Train Model

Predict

Applying: Object Recognition

Complex example

SEARCH BOX

SEARCH BUTTON

CART ICON

All

Departments · Browsing History · Today's Deals · Gift Cards · Registry · Sell

EN · Account & Lists · Orders · Cart 1

Shopping Cart

Price · Quantity

Artificial Intelligence: A Modern Approach (3rd Edition) $102.97
by Stuart Russell
Hardcover
In Stock
✔prime
Prime member exclusive
☐ This is a gift Learn more
Delete | Save for later

PRICE

PRODUCT

Subtotal (1 item): $102.97

Subtotal (1 item): $102.97
☐ This order contains a gift

Proceed to checkout

CHECKOUT

Applying: Object Recognition

ML-based element selection raises level of abstraction

Test scripts are reusable across applications

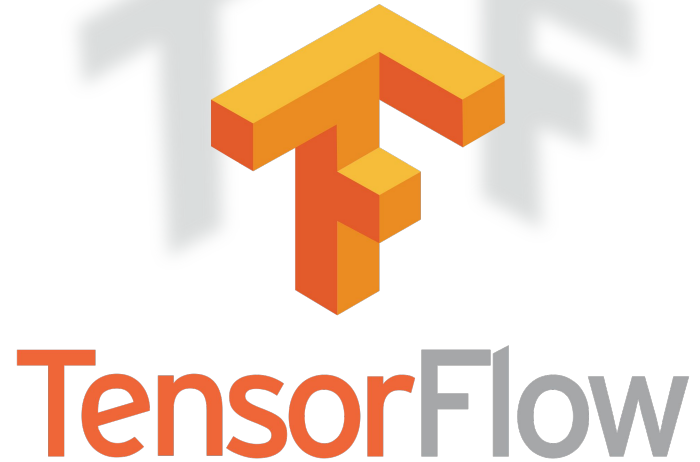Self-healing test scripts that are resilient to styling changes to SUT

Object Recognition: Getting Started!

Can Detect Objects, Now What?

Having the ability to detect objects using ML is a step in the right direction

Bug classification

But, how do we capture how these objects interact?

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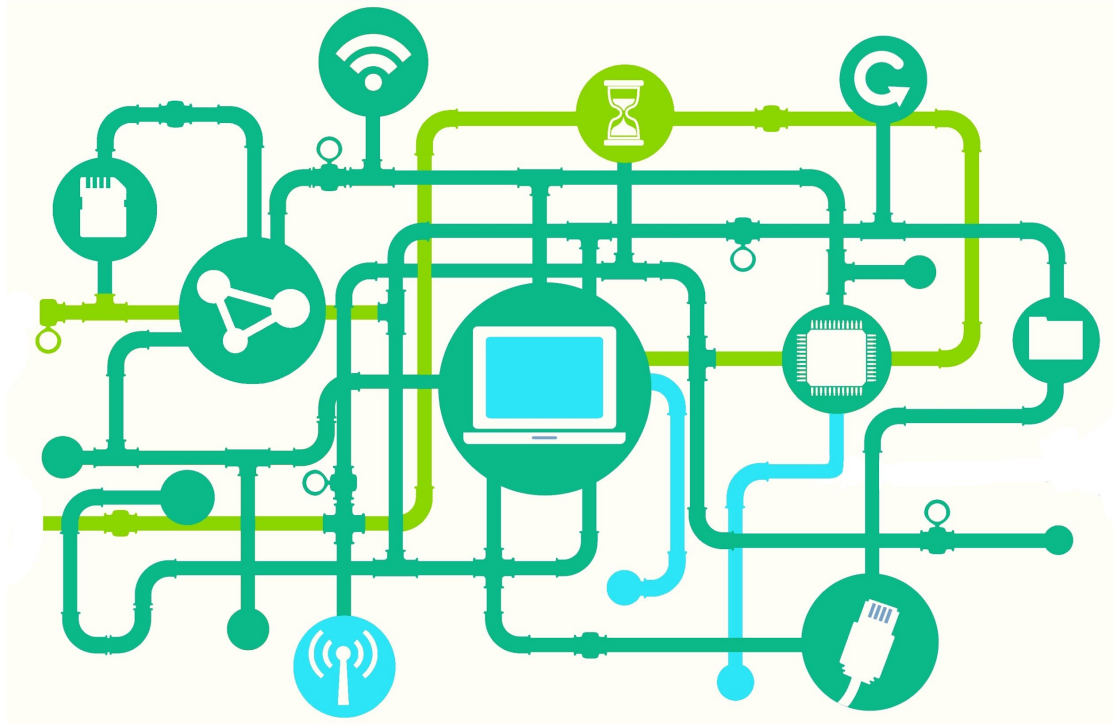
Research: Text Generation

Text Generation with LSTM Recurrent Neural Nets
Jason Brownlee, Ph.D.
machinelearningmastery.com

Research: Text Generation

Sentences are generated by training an ML system to predict "next words":

Applying: Text Generation

Can we model testing as a "sequence"? (Test Flow)

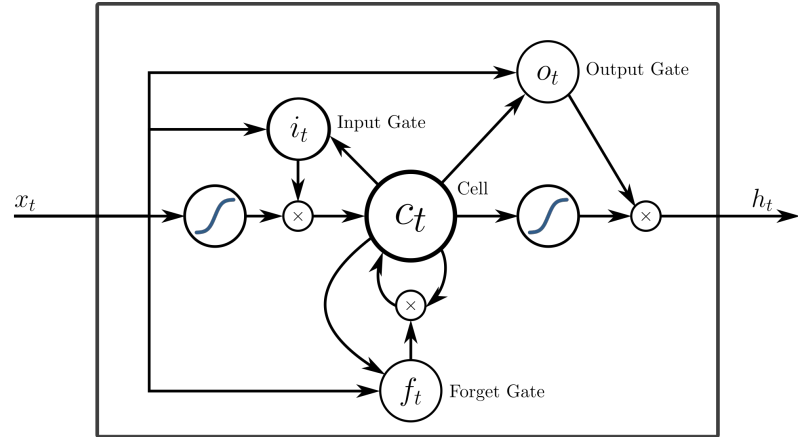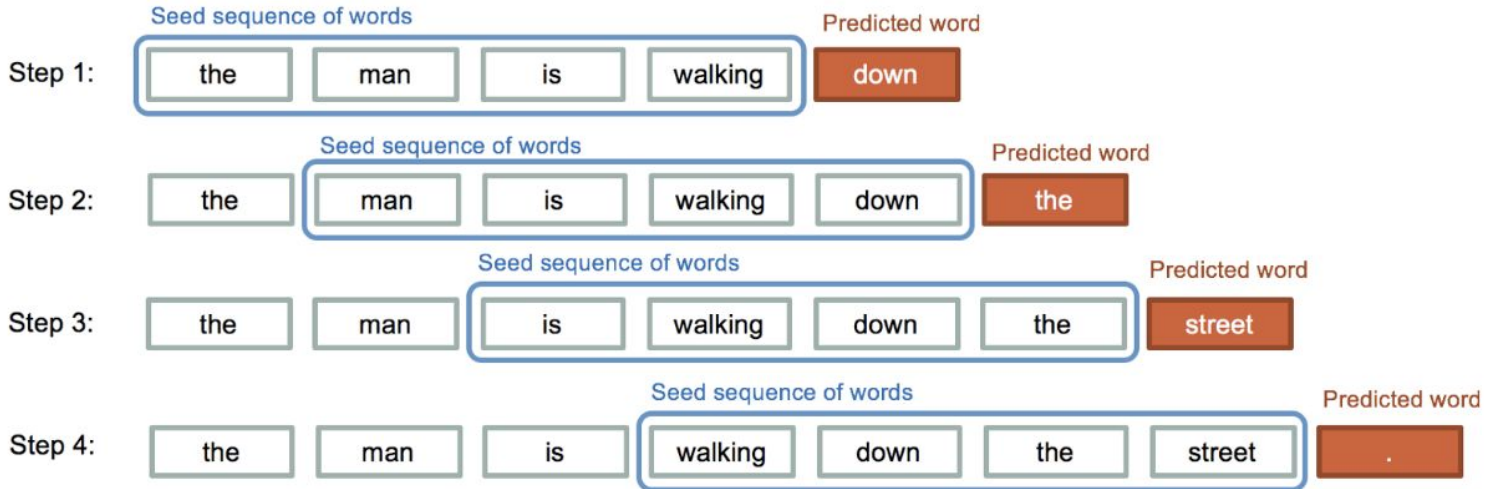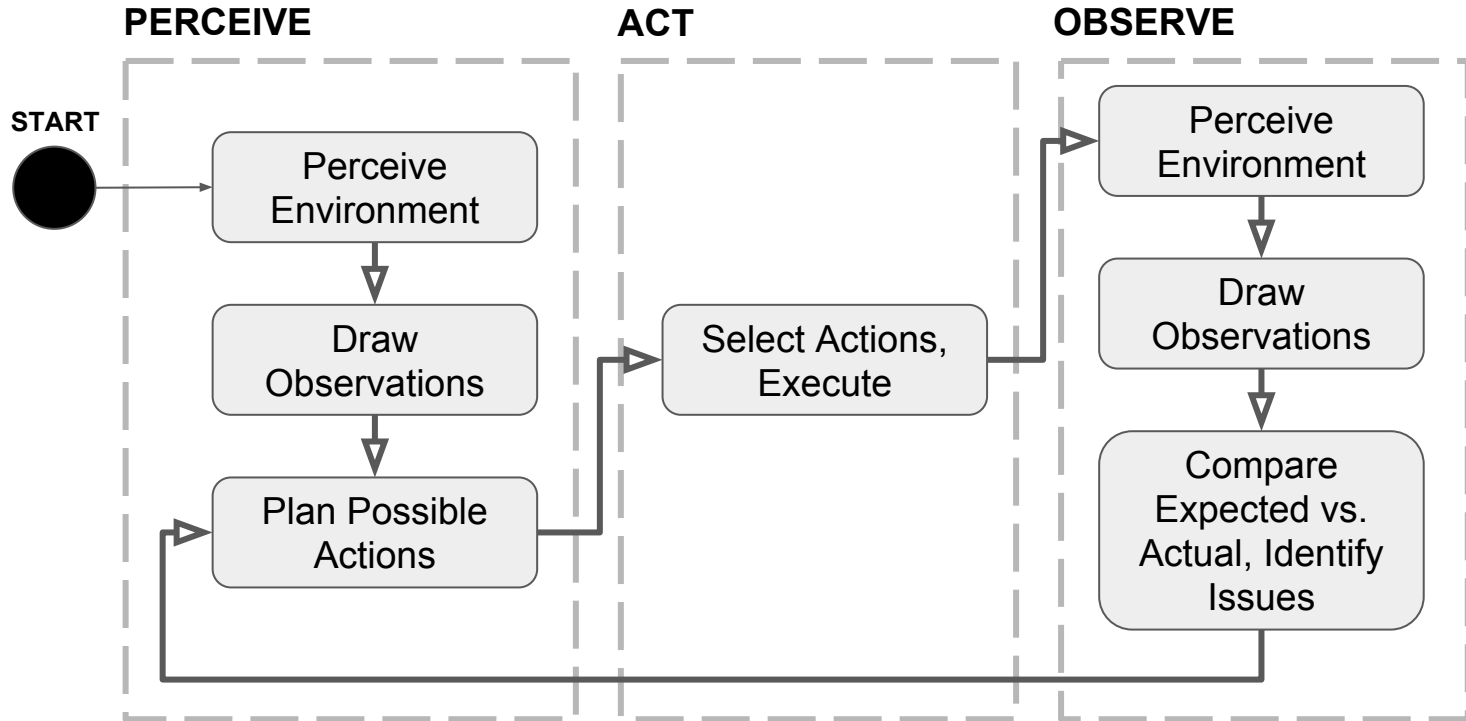# Applying: Text Generation

Can we model these sequences (test flows) using a language?

First Name* **Please enter first name.**   **Last Name*** **Please enter last name.**

Your First Name   Your Last Name

Company

Company   SUBMIT

Observe Required TextBox FirstName   **Input** BLANK FirstName Click Commit   **Observe** ErrorMessage

PERCEIVE   **ACT**   **OBSERVE**

Applying: Text Generation

Can we apply ML techniques to generate test flows?

Observe Required Textbox *FirstName* Try VALID *FirstName* Click *Commit* NotObserve *ErrorMessage*

| 0 | 1 | 2 | 3 | 4 | 5 | 3 | 6 | 7 | 8 | 9 |

TRAIN

| 0 | 1 | 2 | 3 |

| 4 | 5 | 3 | 6 | ... |

PREDICT
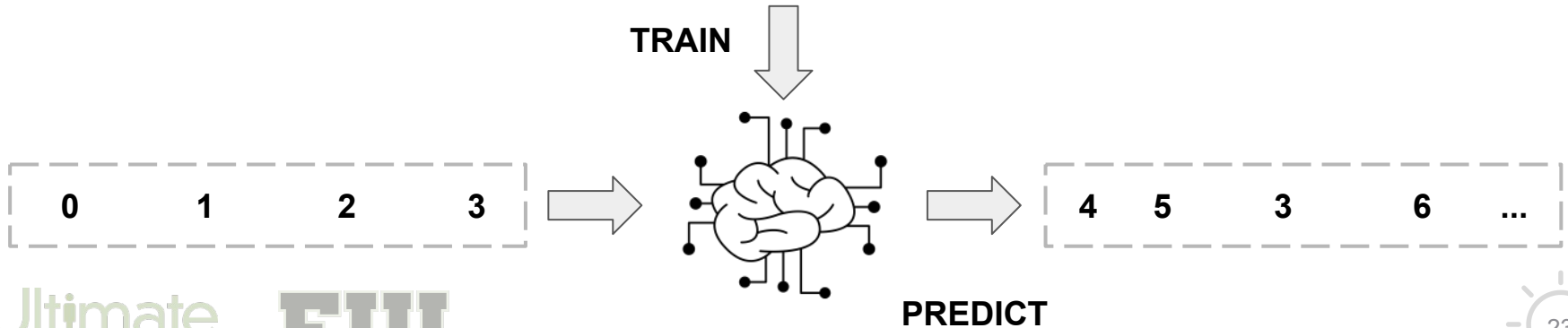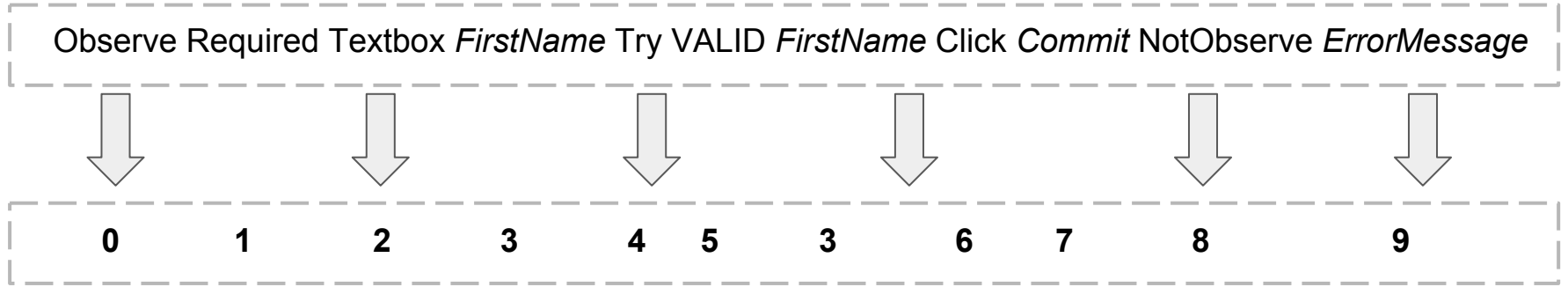
Applying: Text Generation

Shopping Cart

Price   Quantity

Artificial Intelligence: A Modern Approach (3rd Edition)
by Stuart Russell
Hardcover
In Stock
✓prime
Prime member exclusive
☐ This is a gift Learn more

Delete | Save for later

$102.97   1

PRICE   **QUANTITY**

DELETE PRODUCT   **PRODUCT**

Subtotal (1 item) $102.97
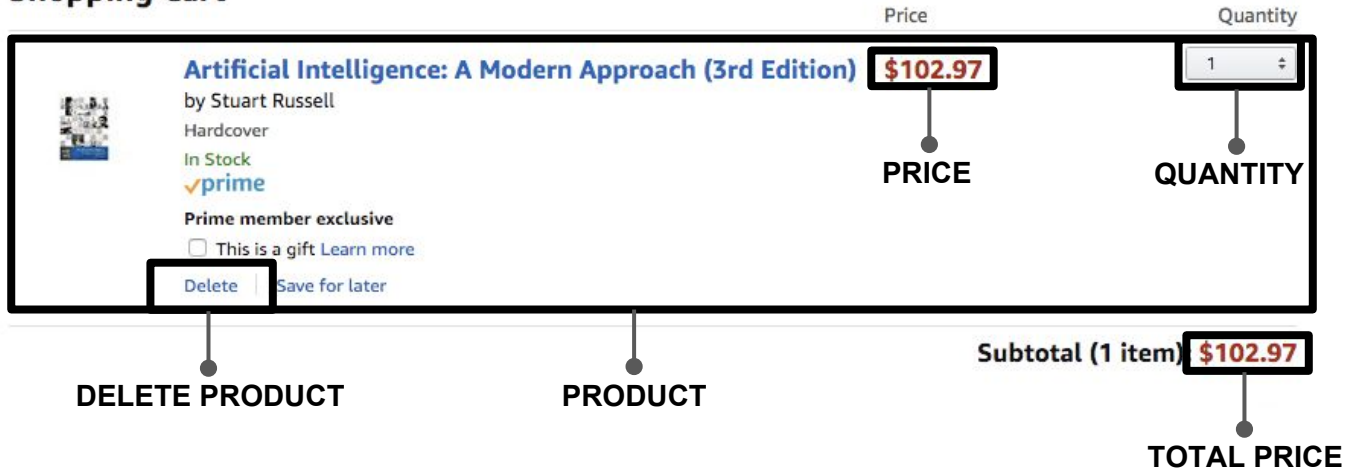
TOTAL PRICE

Observe Screen *ShoppingCart*
Focus *Product* In *Collection*
Try Click *Delete Product*
Observe *Product* Not In *Collection*

Observe Screen *ShoppingCart*
Focus *Product* In *Collection*
Try Increase *Product Quantity*
Observe Increase In *Total Price*

Applying: Text Generation

Train ML system to generate strings in language

```
------ Generating text after Epoch: 1

------ Diversity: 0.2
observe required textbox firstname try click commit errormessage errormessage errormessage errormessage

------ Diversity: 0.5
observe required textbox firstname try textbox click commit errormessage errormessage errormessage

------ Diversity: 1.0
observe required textbox firstname try click commit errormessage errormessage commit errormessage

------ Diversity: 1.2
observe required textbox firstname try whitespace try click commit primaryphone commit
```

Generated strings represent test flows

```
----- Generating text after Epoch: 49

----- Diversity: 0.2
observe required textbox firstname try blank firstname click commit observe errormessage

----- Diversity: 0.5
observe required textbox firstname try invalid_xsr firstname click commit observe errormessage

----- Diversity: 1.0
observe required textbox firstname try valid firstname click commit notobserve errormessage

----- Diversity: 1.2
observe required textbox firstname try whitespace firstname click commit observe errormessage
```
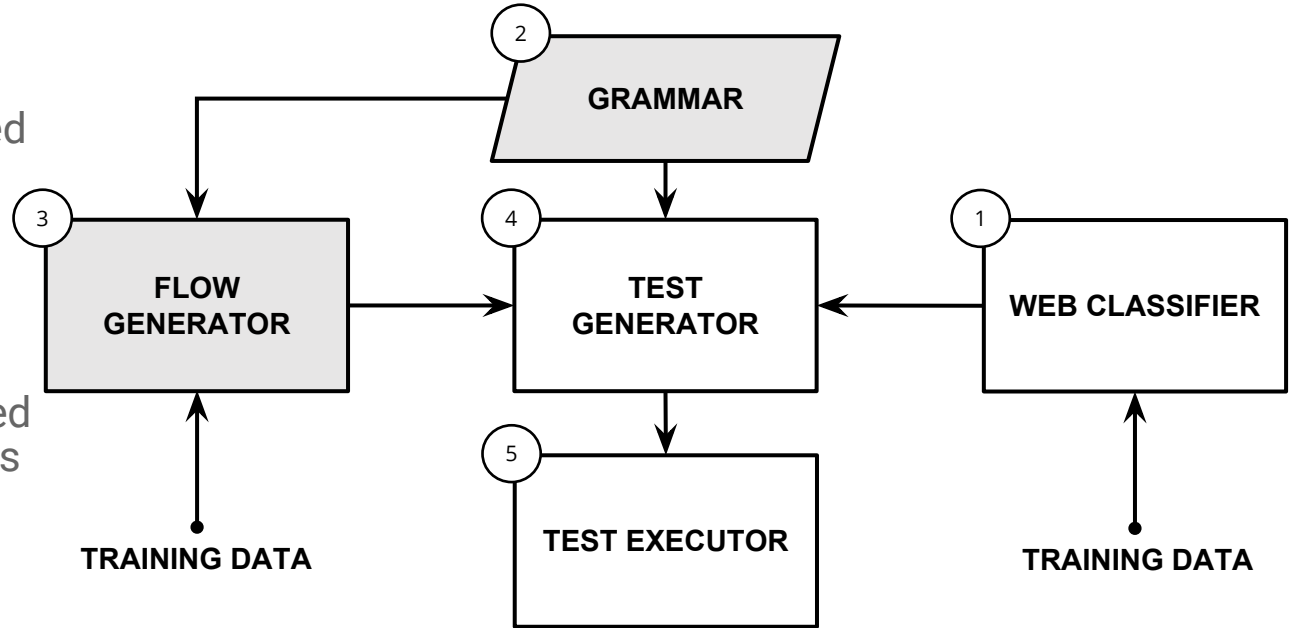
AI-Driven Test Generation

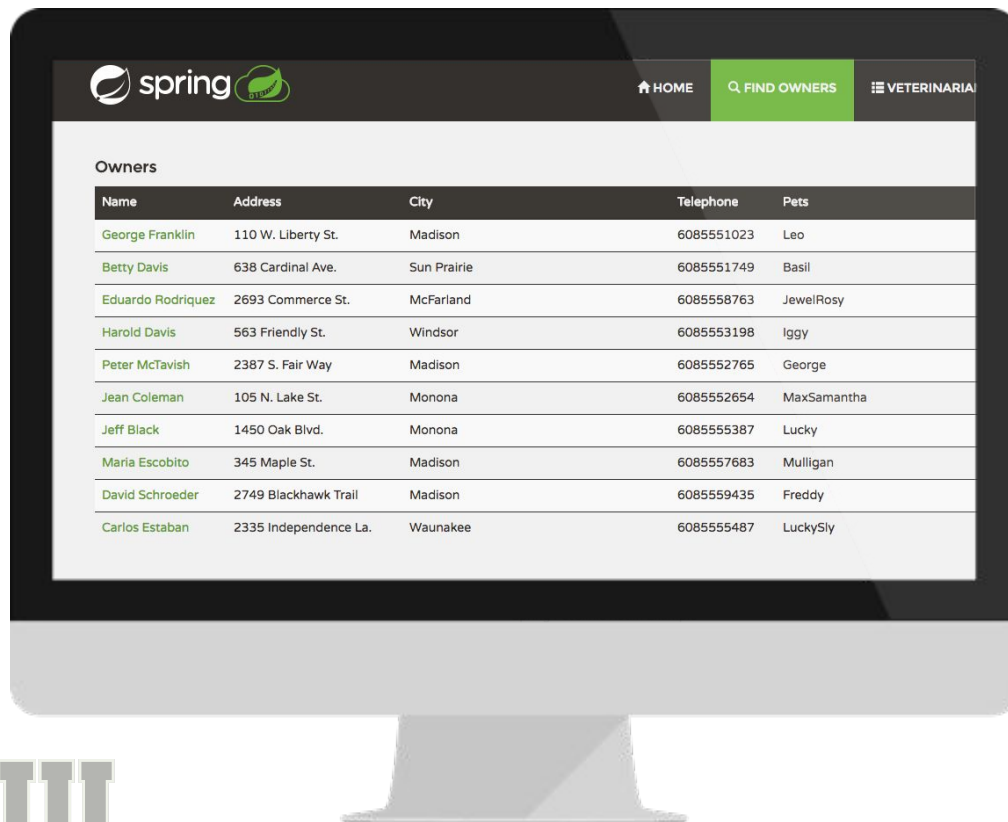Web classifier trained by human testers

Test flow generator trained by human testers

Test flows refer to web elements via labels (reusable across SUTs)

Language grammar is used to convert generated flows to executable test cases

AI-Driven Test Generation (Demo)

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State of the Art

Breaking into AI

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State of the Art
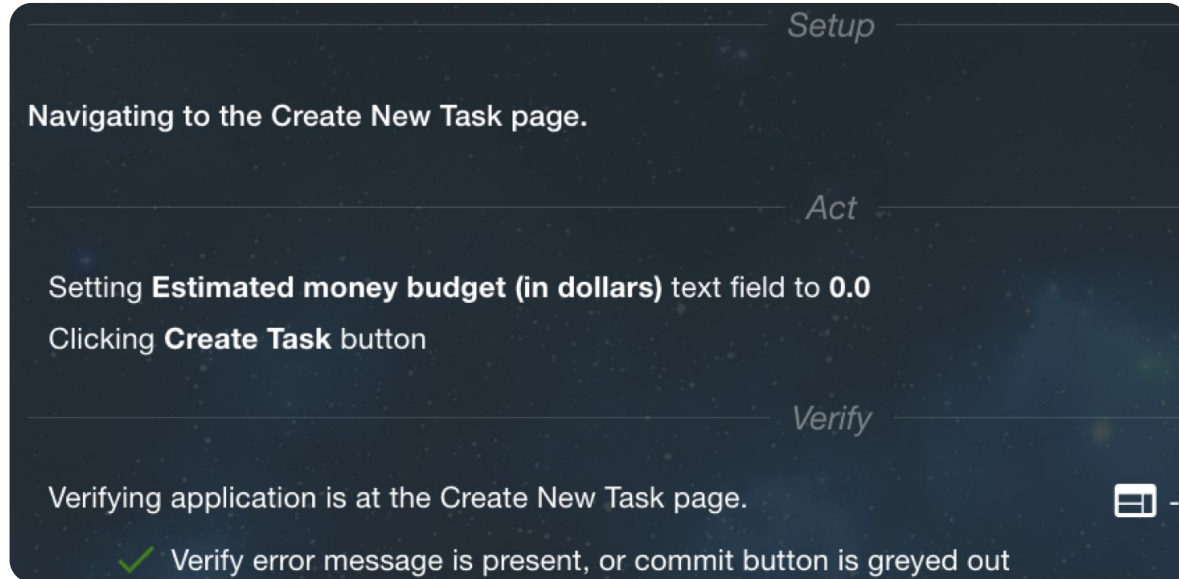
http://mabl.com

http://test.ai

http://applitools.com

http://eggplant.io

State of the Art

Automatic system exploration

State of the Art

Automatic human-readable test case generation

State of the Art

Human-trainable knowledge base for domain rules

| | Seed Rules | Inferred Rules | Questions | Labelling | Graph | NLP Analysis |

Ask Questions   Search Expression...

ID	Value	Operator	Decision
1	Jasper O.	has a	Car
2	Oliver M.	is never a	STE
3	Mia J.	has one	Car

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Open Challenges

Despite the progress that has been made...

How do we reliably generate meaningful test inputs for the infinitely possible combinations?

For deeper domain-specific knowledge, how do we train the bots to know what to expect of a system?
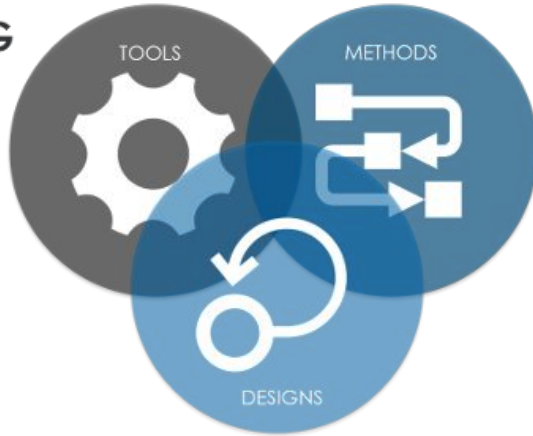
How do we create systems capable of autonomously learning and comparing behavior for intra-domain SUTs?

One step at a time... **together.**

Important Problems

AI TESTING · TOOLS · METHODS · TESTING AI

SELF-TESTING · DESIGNS

AISTA
aitesting.org

Breaking into AI (MOOCs)

Machine Learning

About this course: Machine learning is the science of getting
programmed. In the past decade, machine learning has given
recognition, effective web search, and a vastly improved unde
learning is so pervasive today that you probably use it dozens

⌄ More

Created by: Stanford University

Stanford
University
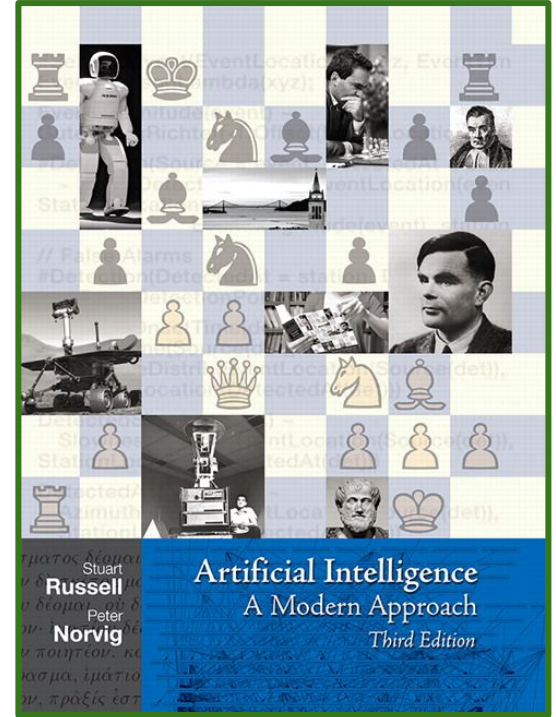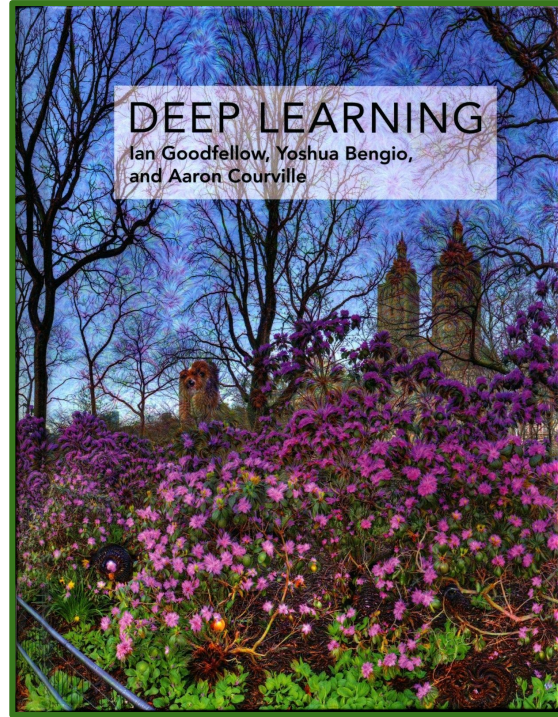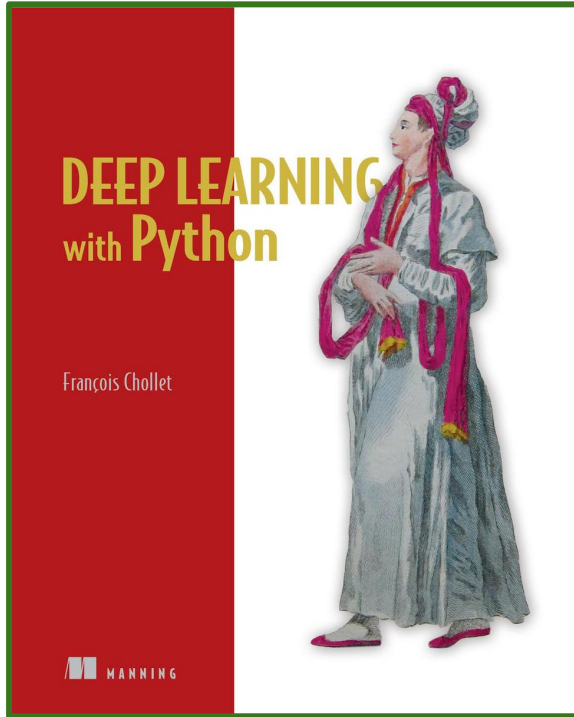
Deep Learning Specialization

Master Deep Learning, and Break into AI

NANODEGREE PROGRAM

Become a Machine Learning Engineer

In this program you will master Supervised, Unsupervised, Reinforcement, and Deep Learning
fundamentals. You will also complete a capstone project in your chosen domain.

Breaking into AI (Books)

Breaking into AI (Presentations)

Jason Arbon, "**AI and Machine Learning for Testers**", PNSQC 2017

Tariq King, Keynote "**Rise of the Machines: Can Artificial Intelligence Terminate Manual Testing?**", StarWest 2017

Paul Merrill, "**Machine Learning & How It Affects Testers**", Quality Jam 2017

Geoff Meyer, Keynote "**What's Our Job When the Machines Do Testing?**", StarEast 2018

Angie Jones, Keynote "**The Next Big Things: Testing AI and Machine Learning Applications**", StarEast 2018

Jason Arbon and Tariq King, "**Artificial Intelligence and Machine Learning Skills for the Testing World**", StarEast 2018

Closing Remarks

The Bots Are Here

Ripe New Intersection

Break Into AI, and Get Involved!

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Acknowledgements

Patrick Alt	**Jason Arbon**
David Adamo	**John Maliani**
Keith Briggs	**Robert Vanderwall**
Justin Phillips	**Michael Mattera**
Philip Daye	**Brian Muras**
Keith Stobie	**Rick Anderson**

Thank you!