

BPS5231

Artificial Intelligence

For

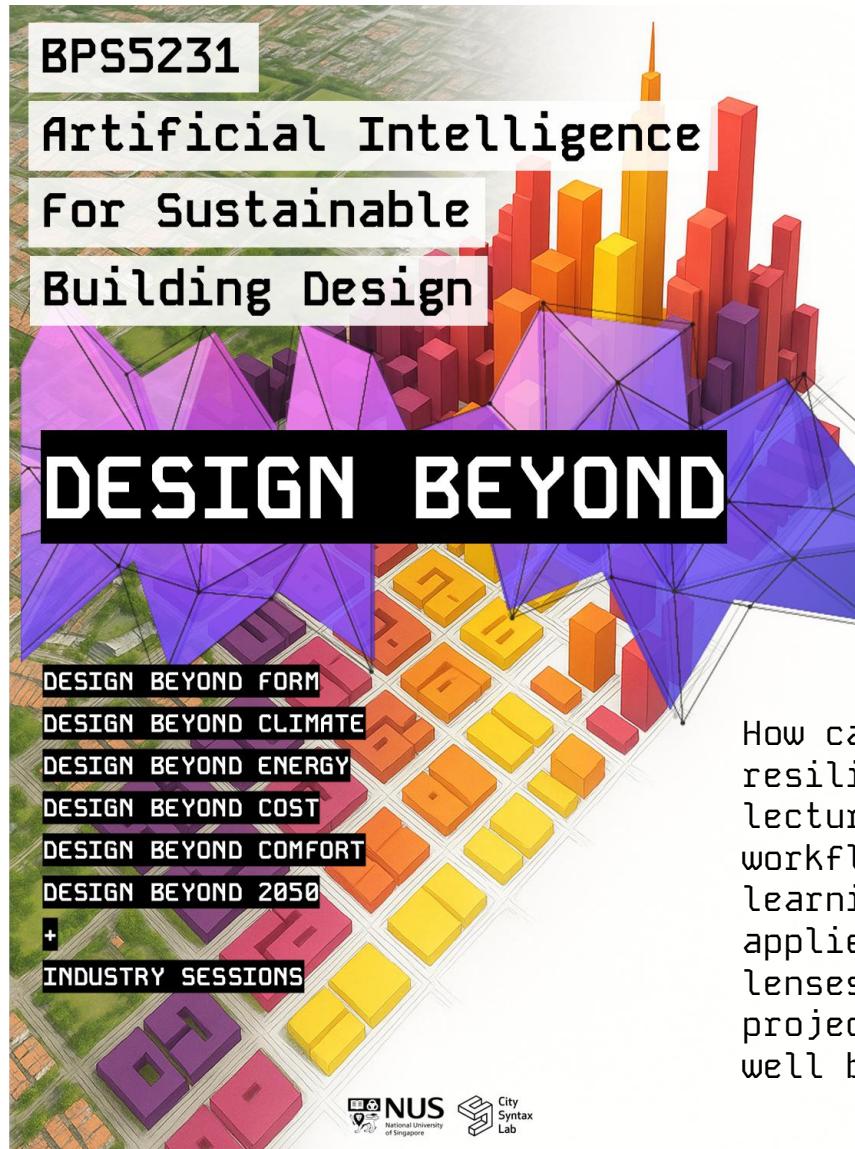
Sustainable

Building

Design

Ang Yu Qian

Assistant Professor



How can we leap past today's limits to develop climate-resilient, human-centric buildings and cities? This studio-lecture hybrid equips participants with a suite of AI workflows – data-driven simulation, generative AI, deep-learning surrogates, and large-language-model copilots – applied through a series of provocative weekly “Design Beyond” lenses. Design-and-code labs, expert critiques, and a capstone project that demonstrates how AI can move sustainable design well beyond today's boundaries.

Welcome Message



INTRODUCTION

BASCIS

APPLICATIONS

L01.1

Introduction

First things first

Course Details

Who are we?

Who are you?

Class Organization

L01.2

Basics

Buildings

History of AI

Machine Learning Basics

L01.3

Applications

Examples

Design Beyond Space

L01.1

Introduction

First things first

Course Details

Who are we?

Who are you?

Class Organization

L01.2

Basics

Buildings

History of AI

Machine Learning Basics

L01.3

Applications

Examples

Design Beyond Space

First things first

No listeners/auditors
I won't stop you from sitting in, but
there will be zero support.

My wife is teaching AR5958A. She is nicer than me,
maybe she will let you audit.

First things first

I am not admin

You will need to code

Vibe coding is fine, this is an AI course, but you need to know what the model is generating. Repeatedly using ChatGPT/Claude/DeepSeek without thinking will make you stupid

The screenshot shows the homepage of The Economic Times Panache. At the top, there are buttons for 'My Watchlist', 'Subscribe', and 'Sign In'. A red banner at the top right says 'Freedom Offer : 50% OFF!'. The main navigation bar includes links for Home, ETPrime Markets, Market Data, AI Masterclass, News, Industry, SME, Politics, Wealth, MF, Tech, AI, Careers, Opinion, NRI, Panache, and a search icon. Below the navigation, a secondary menu shows 'Luxury' and 'Panache'. The main content area features a large headline: 'Is ChatGPT making us dumb? MIT brain scans reveal alarming truth about AI's impact on the human mind'. Above the headline, the Panache logo is displayed.

First things first

We will be doing
modeling & simulations

First things first

This will be hacky

It's a new course. It's AI. Things will go wrong.

Assessment

Class participation: 10%

Project: 90%

(Deliverables – Code or Repo + Slides + Conf. Paper)

No recordings (venue + logistical limitation)

No attendance taking

No make-up classes

No weekly psets (hands-on lab + interim submissions)

Office hours will be announced

The slide is titled "Buildings and Urban Intelligence" by Mayuri Rajput. It features a diagram illustrating the hierarchy of urban components: Urban Fabric, Block, Lot / Parcel, and Building. Below the diagram, it says "HARVARD UNIVERSITY GRADUATE SCHOOL OF DESIGN". The slide is presented on a dark background with a navigation bar at the bottom.

Mayuri Rajput

Buildings and Urban Intelligence

Urban Fabric

Block

Lot / Parcel

Building

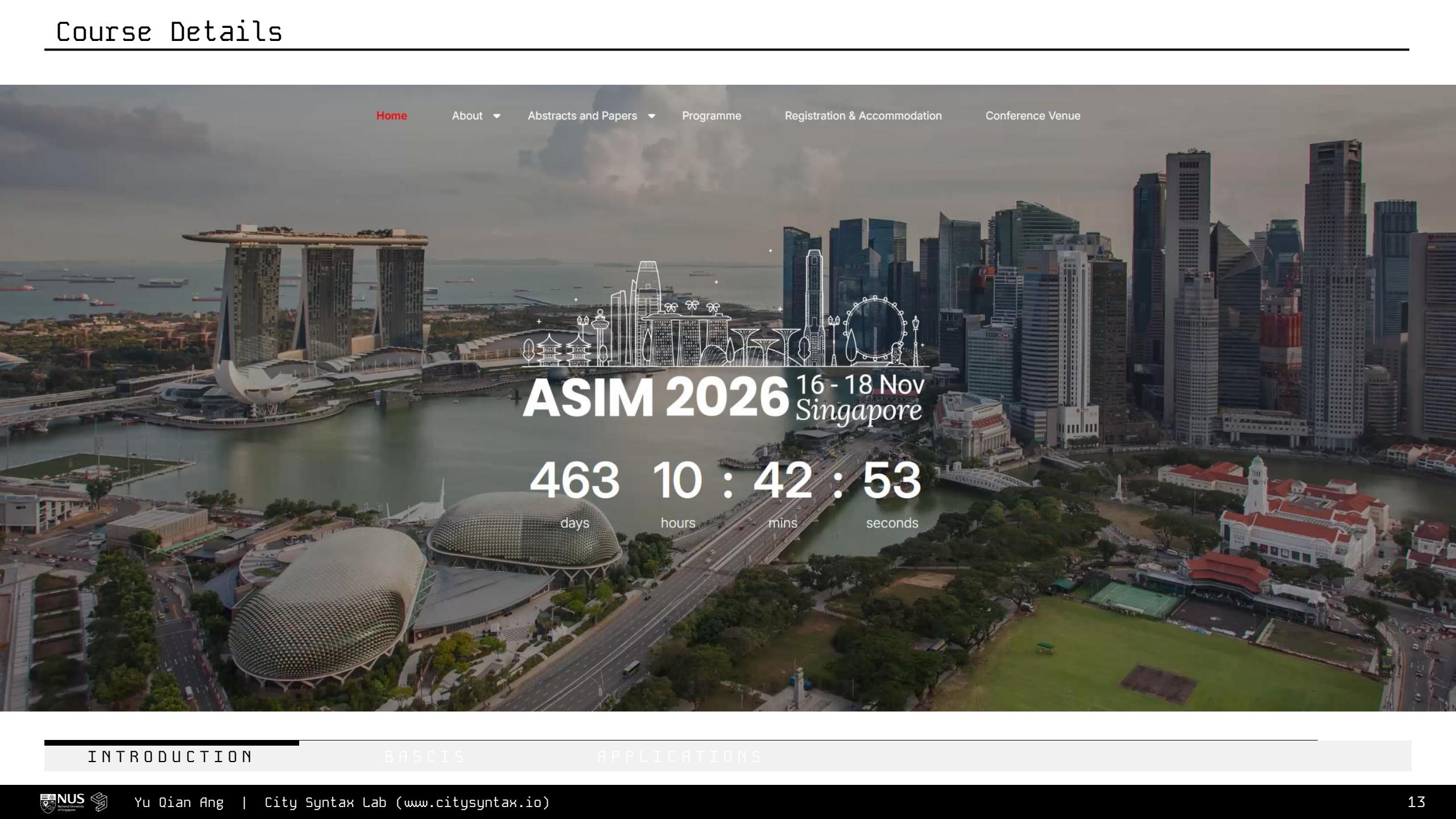
HARVARD UNIVERSITY GRADUATE SCHOOL OF DESIGN

1 / 38 issuu

INTRODUCTION BASCIS APPLICATIONS

Course Details

[Home](#) [About](#) ▾ [Abstracts and Papers](#) ▾ [Programme](#) [Registration & Accommodation](#) [Conference Venue](#)



ASIM 2026 16 - 18 Nov
Singapore

463 10 : 42 : 53

days

hours

mins

seconds

INTRODUCTION

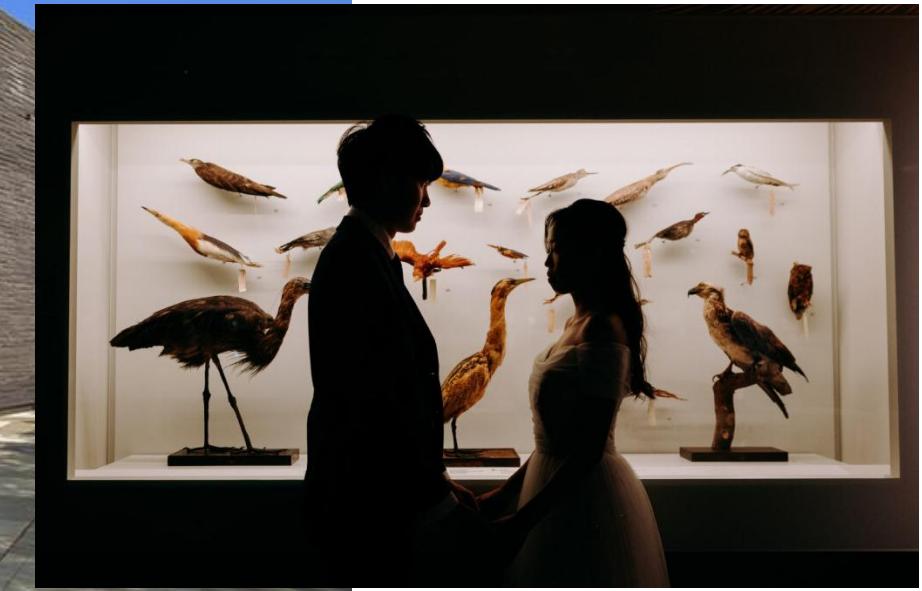
BASCIS

APPLICATIONS

Potential Site Visits + Industry Talks



Possible Project



INTRODUCTION

BASCIS

APPLICATIONS

Software



LADYBUG



HONEYBEE



BUTTERFLY



DRAGONFLY



GitHub

Building Technology Press

Our Books My Library About Sign up Log Out

BT World

Welcome. Click on any of the flipbooks below to start reading.

Daylighting Handbook I
Fundamentals
Designing with the Sun
Christoph Reinhart

Daylighting Handbook II
Daylight Simulations
Dynamic Facades
Christoph Reinhart

Climate Driven Design I
Building Energy Use
Climate and Comfort
Passive Design
Christoph Reinhart

Please note that the Climate Driven Design book is still work-in-progress and consists of five out of what will ultimately be eight chapters.

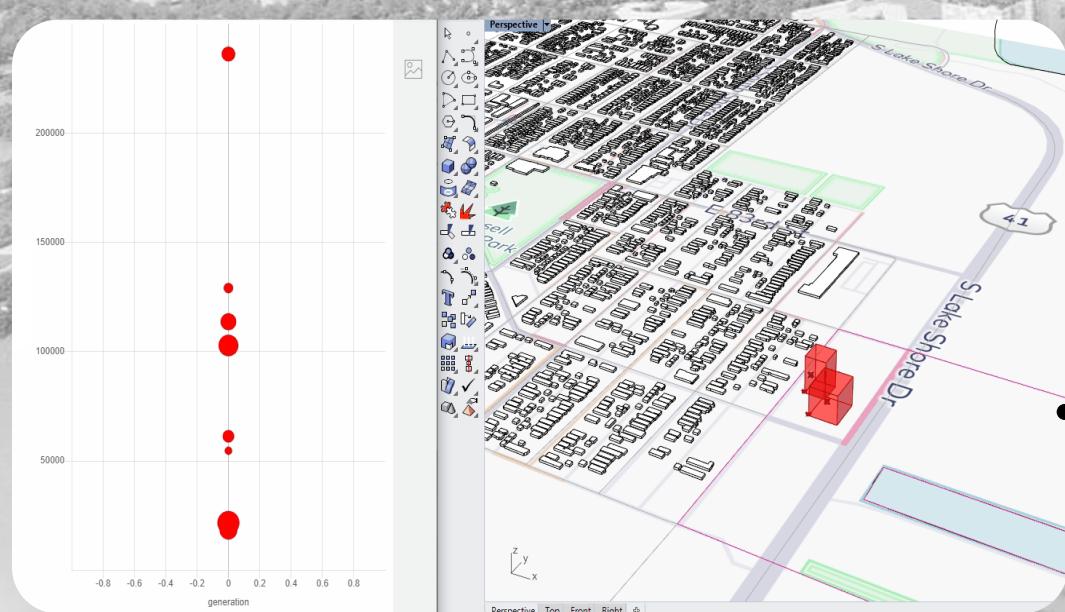
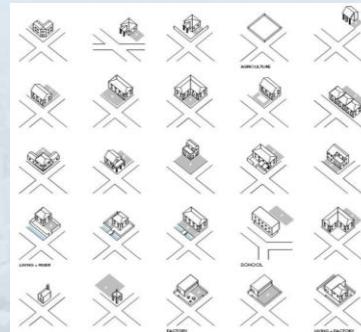
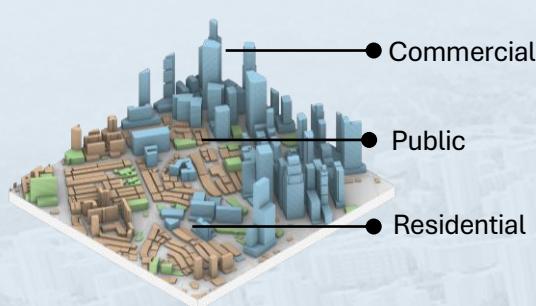
Your member status is BT World subscriber and will be valid until January 11, 2025.

Questions?

Who are you?

Go to
<https://bit.ly/BPS5231-class>

Simulating a thousand cities



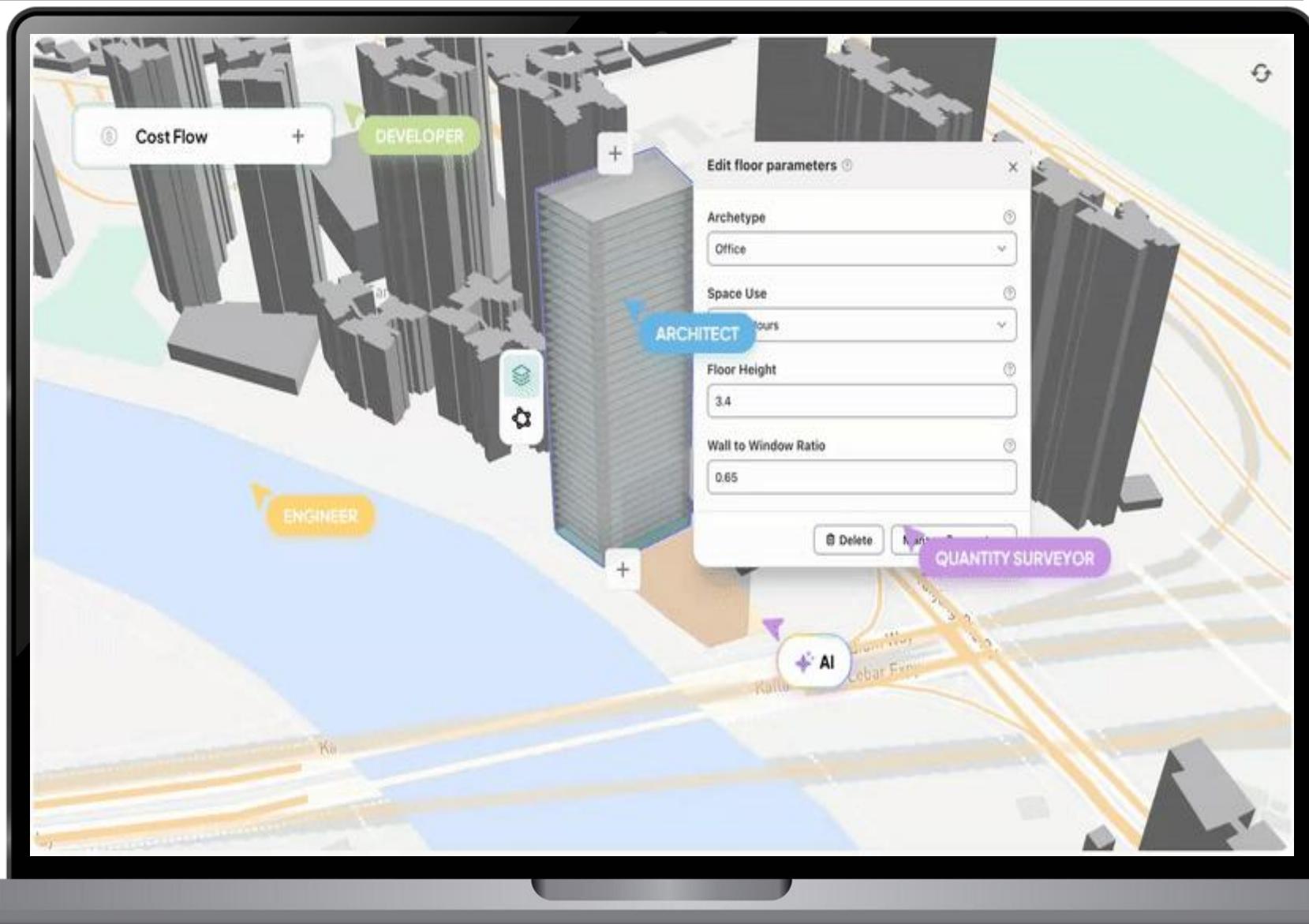
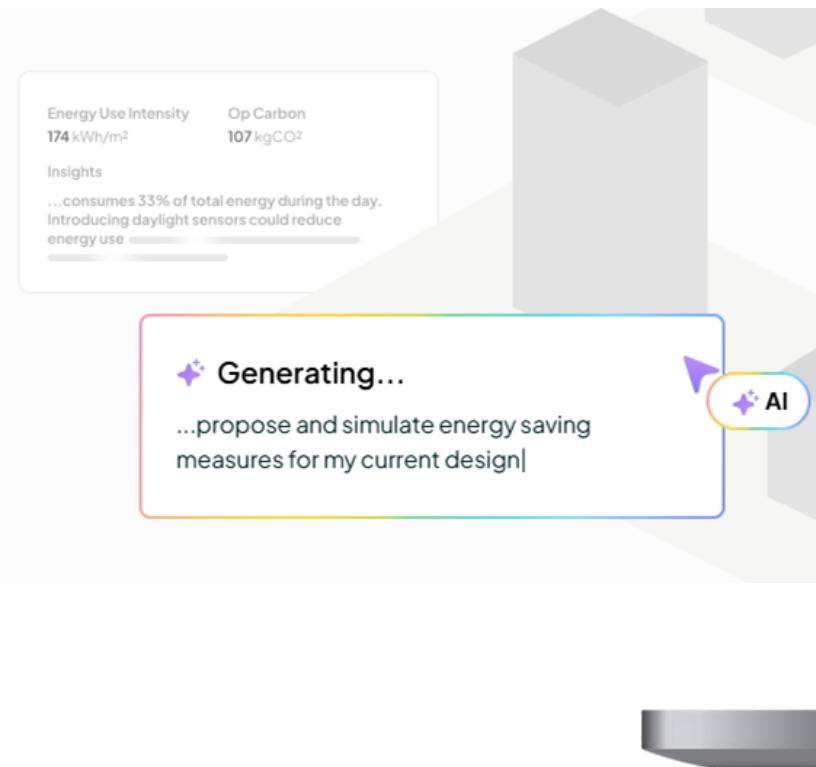
AI decarbonization model for Jurong Lake District



URBANFLOW

AI Agents

Each a different expert



L01.1

Introduction

First things first

Course Details

Who are we?

Who are you?

Class Organization

L01.2

Basics

Buildings

History of AI

Machine Learning Basics

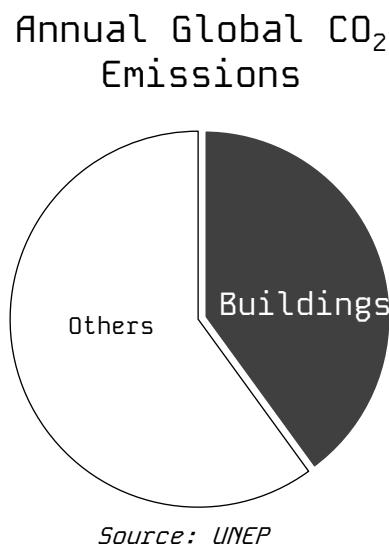
L01.3

Applications

Examples

Design Beyond Space

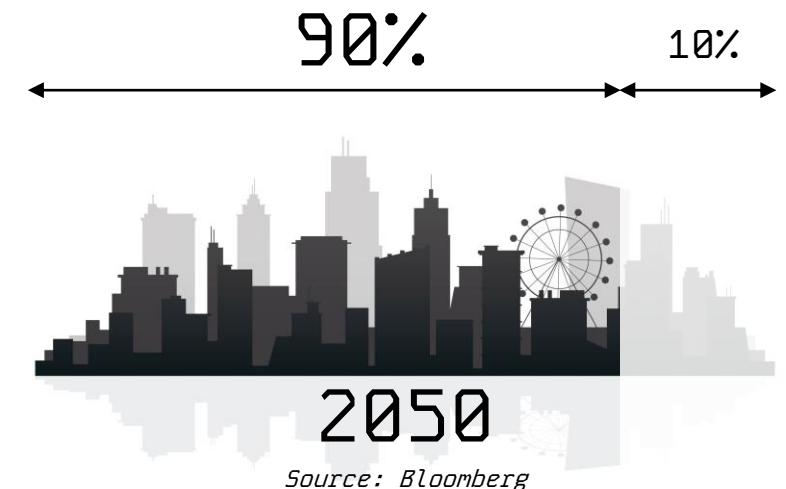
~40% of energy use &
of annual CO₂ emissions



Global building floor area expected to double
(230 billion m² new GFA)



Around 90% of existing buildings are expected to still be here in 2050







Source: Kelvin Ang Kah Eng



Source: Kelvin Ang Kah Eng





Universal drafting machine, combining T-square, triangles, scales, and protractor



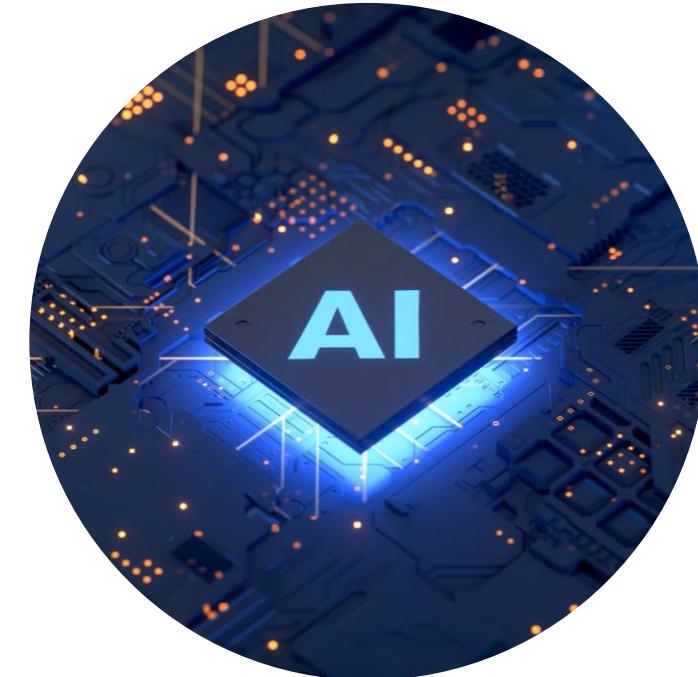
Old drafting table for architecture and engineering drafters to produce drawings



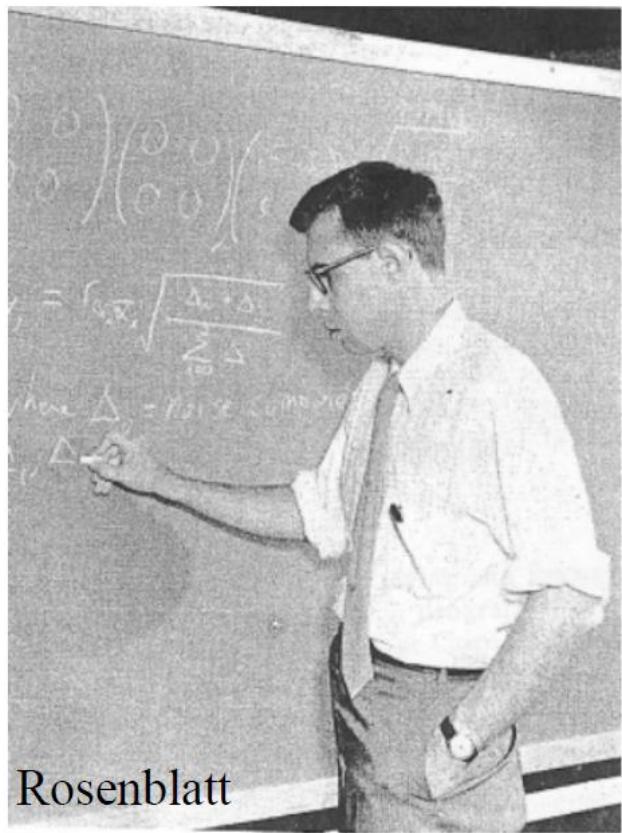
Calma Digitizer workstation introduced in 1965 allowed coordinate data to be entered and transferred to computers



One of the early generation of CAD systems



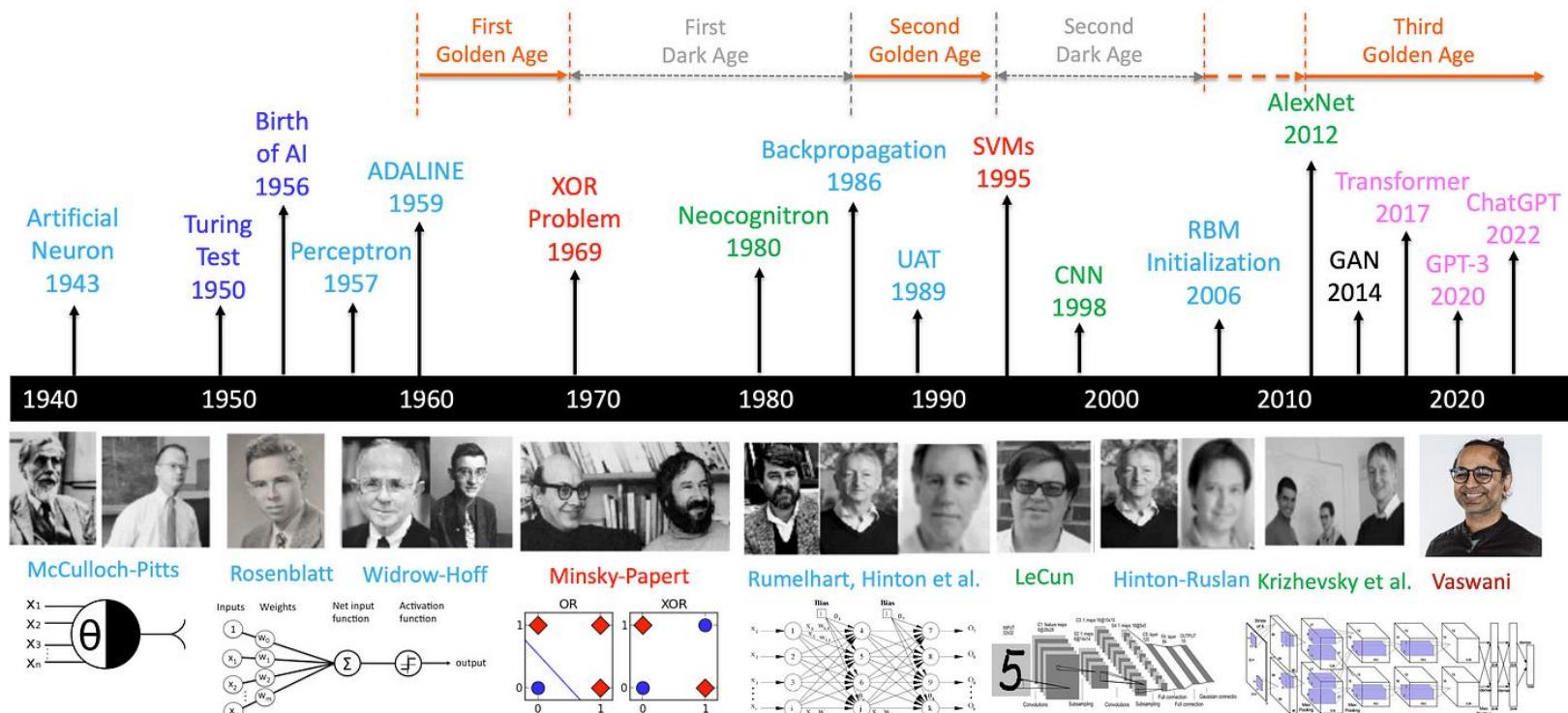
Perceptrons, 1958



http://www.ecse.rpi.edu/homepages/nagy/PDF_chrono_2011_Nagy_Pace_FR.pdf. Photo by George Nagy

Neural Networks date back decades, so why now?

1. Big Data



2. Hardware

3. Software

ARTIFICIAL INTELLIGENCE

Any technique that enables computers to mimic human behavior



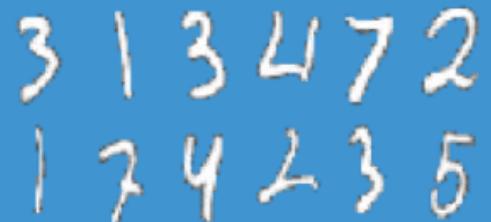
MACHINE LEARNING

Ability to learn without explicitly being programmed



DEEP LEARNING

Extract patterns from data using neural networks



[Arthur Samuel \(1959\)](#): Machine Learning is the field of study that gives computers the [ability to learn](#) without being explicitly programmed.

[Goodfellow et al. \(2016\)](#): Machine Learning is the ability of systems to acquire their own knowledge (as opposed to relying on hard-coded knowledge) by [extracting pattern from raw data](#).

Tom Mitchell (1998): A computer program is said to learn from **experience E** with respect to some **task T** and some **performance measure P**, if its performance on T, as measured by P, improves with experience E.

Example: Your email program watches you label emails as spam or not spam, and based on that learns how to better filter spam.

E: You labeling them as spam or not

T: Classifying emails as spam or not

P: Fraction of emails correctly classified

Simple Definition: Machine Learning is the science of getting computers to learn without being explicitly programmed.

Training Data Setup: We have observed values of input variables X along with the output variable

Example: $X=(\text{Seniority, Years of Education})$, $Y=\text{Income}$

Denote the observations by $i=1,2,\dots,n$

Suppose the input data is p -dimensional

In our example: $p=2$, $n=\text{number of people in the dataset}$

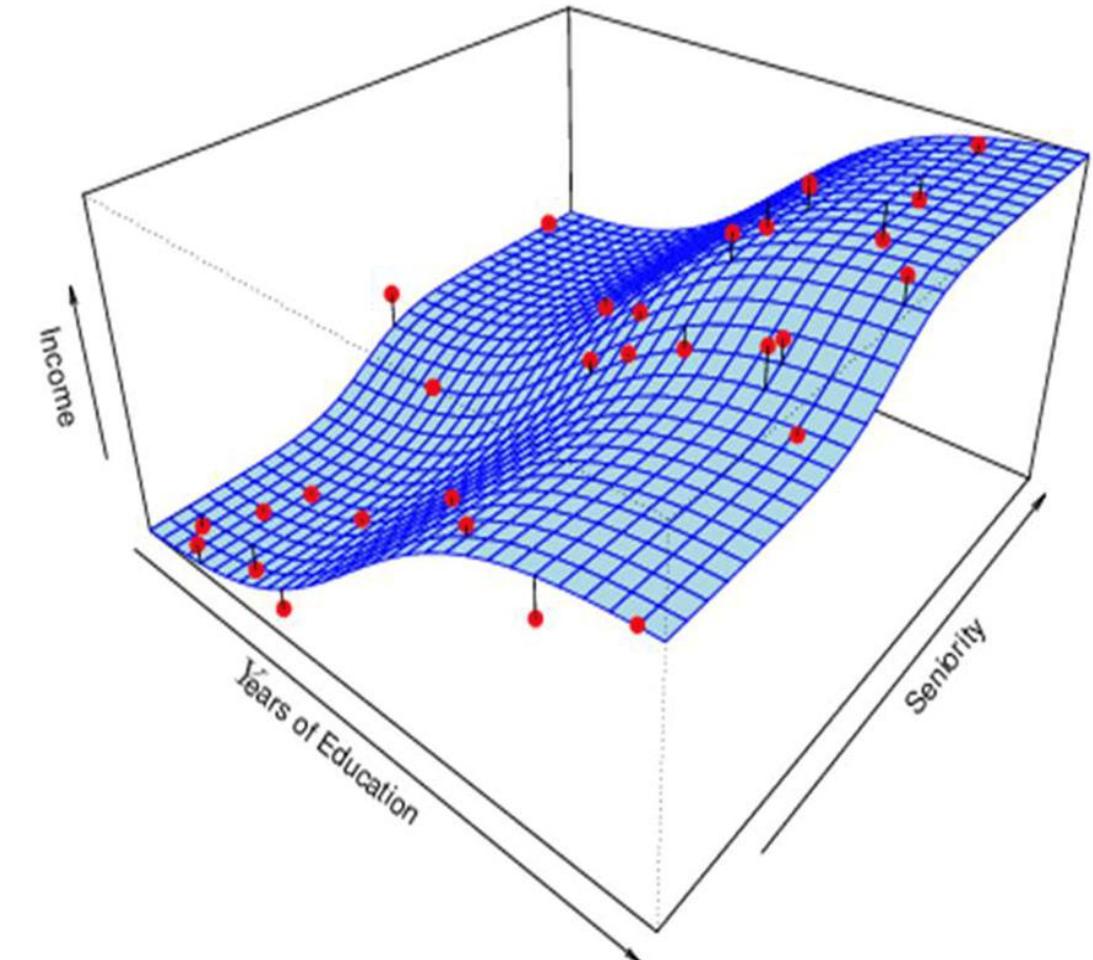
Observation $i(i=1,2,\dots,n)$: $X_i=(X_{i1}, X_{i2}, \dots, X_{ip})$

We believe there is a relationship between Y and X .

$$\text{Income} = f(\text{Seniority}, \text{Education}) + \varepsilon$$

f represents the blue surface.

Red points represent the observed data points.



Why do we want to find f ?

Two main reasons:

Prediction: We can use f to predict values of Y for new value of X (income of a new person).

Inference: We might be interested in the type of relationship between Y and the X 's.

Which predictors affect the response (e.g., what affects income)?

- Is the relationship positive or negative?
- Is the relationship statistically significant?
- Is the relationship a simple linear one, or more complicated?

Our definitions of the two are different.

Machine Learning arose as a branch of Artificial Intelligence in Computer Science.

Statistical Learning arose as a branch of Statistics.

Machine Learning has a greater emphasis on **large-scale** and **real-time data** as well as **prediction accuracy** (sometimes treated as black boxes)

Statistical Learning has a greater emphasis on **model interpretability** and **statistical properties of estimation**.

However, the distinction is not significant now.

Supervised Learning in general

$S_n = \{(x^{(t)}, y^{(t)}), t = 1, \dots, n\}$ = dataset with features and labels (ground truth examples)

\mathcal{H} = hypothesis class (space of functions)

\mathcal{L} = loss function (often squared error for regression) e.g. $\mathcal{L}(x_1, x_2) = (x_1 - x_2)^2$

Goal: pick a function $h \in \mathcal{H}$ that predicts labels y based on features x as accurately as possible

>>> Optimization

ML algorithms always involve optimization (sometimes greedy). Formally:

$$\min_{h \in \mathcal{H}} \sum_{i=1}^n \mathcal{L}(h(x_i), y_i)$$

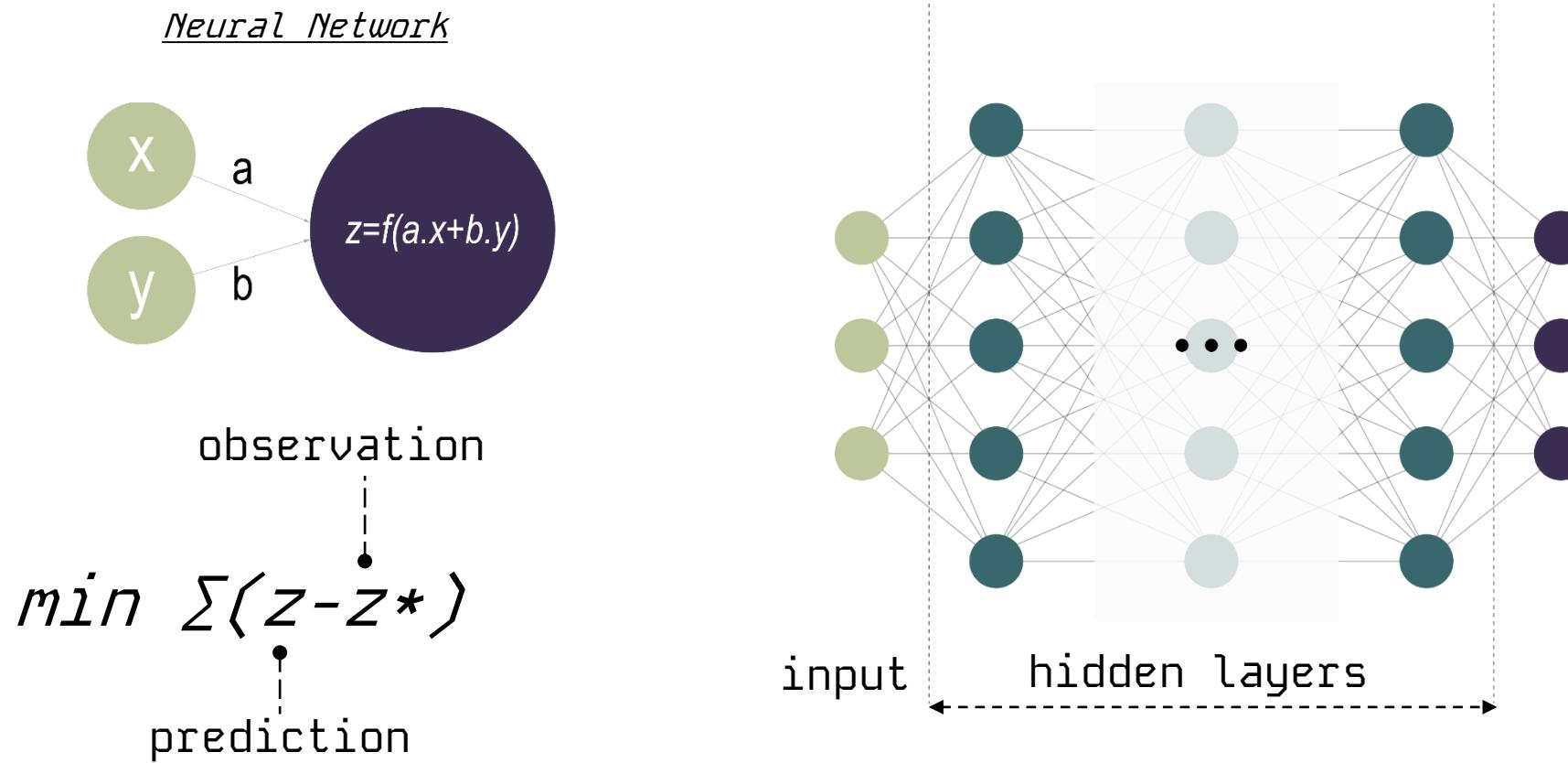
observation

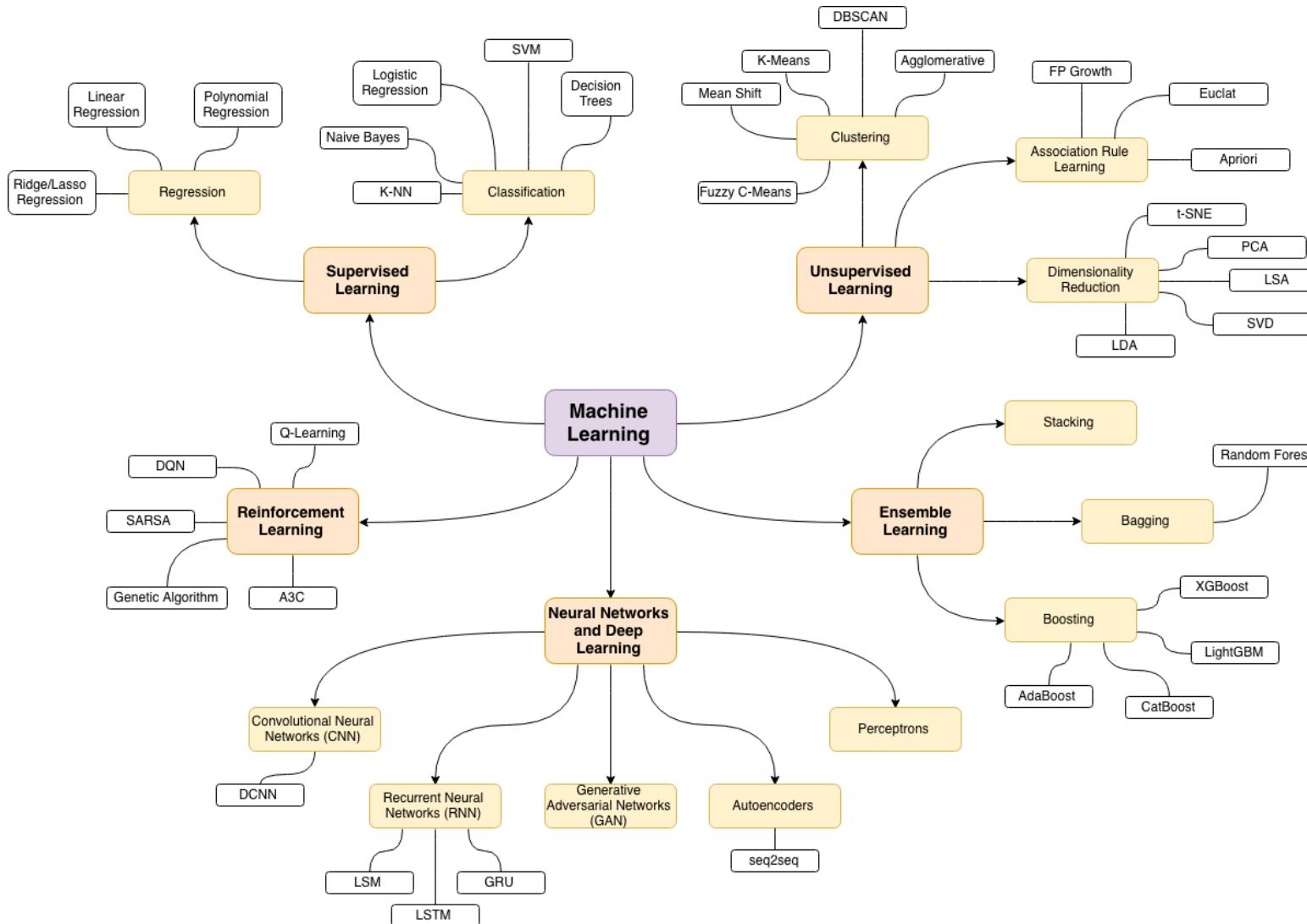
prediction

Minimization over training data but we really want to do well over testing data!
(more on this next weeks)

Neural Network

“Giant Regression” = Universal Function Approximator





Transformers + Agents

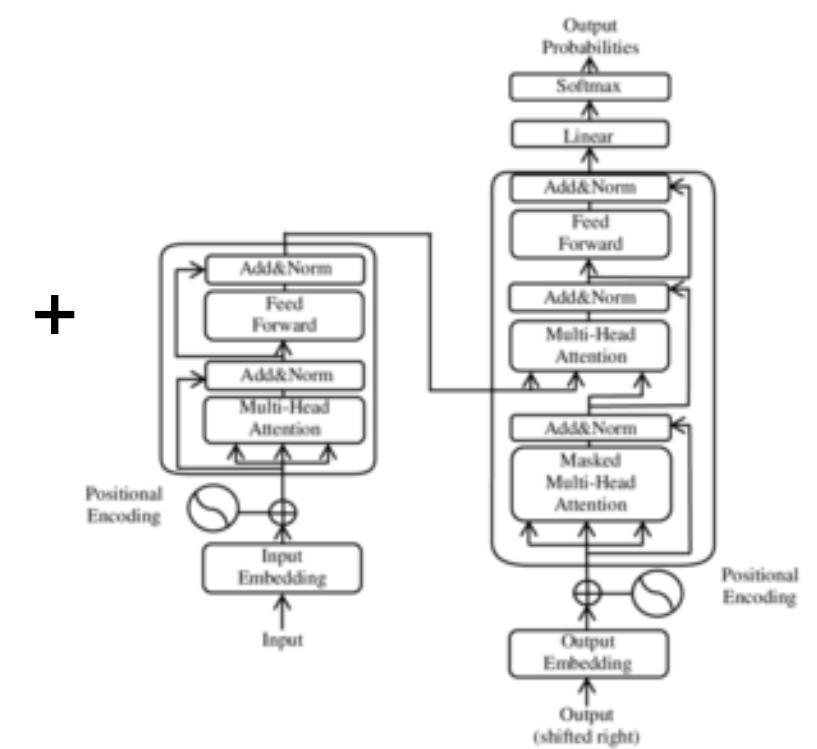
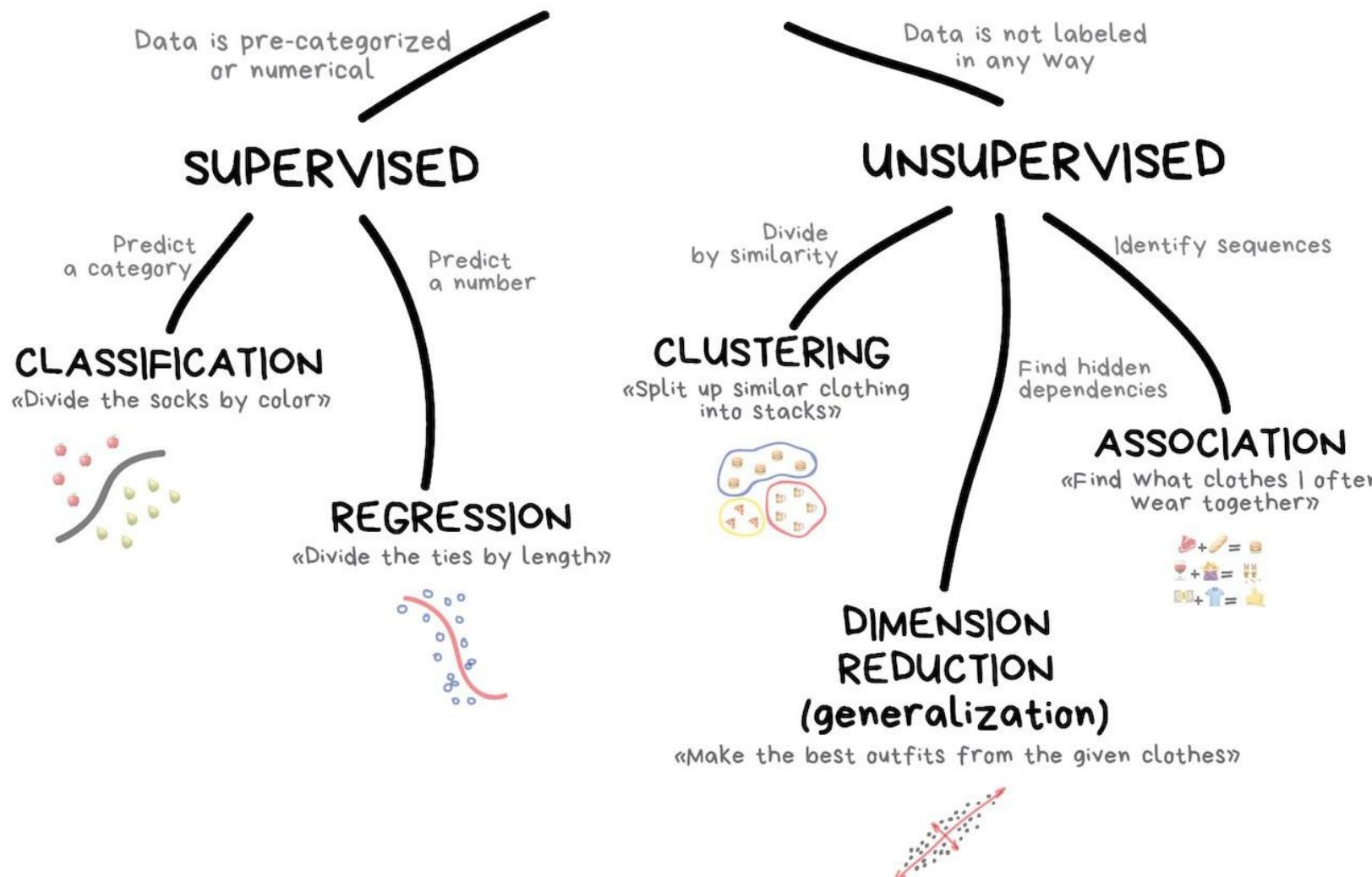


Image from Anil Jain, Google

Go to:
<https://playground.tensorflow.org/>

Go to:
<https://bbycroft.net/llm>

CLASSICAL MACHINE LEARNING



Supervised Learning
Both predictors (X) and response/outcome (Y) are observed or measured

Unsupervised Learning
Only X values are available in the dataset; no output measure

Regression
 Y is continuous/numerical
Example: Y = Income

Classification
 Y is discrete/categorical
Example: Y = Spam or Not Spam

L01.1

Introduction

First things first

Course Details

Who are we?

Who are you?

Class Organization

L01.2

Basics

Buildings

History of AI

Machine Learning Basics

L01.3

Applications

Examples

Design Beyond Space

AI as a tool for designing buildings and cities

Effectively **analyze** complex data

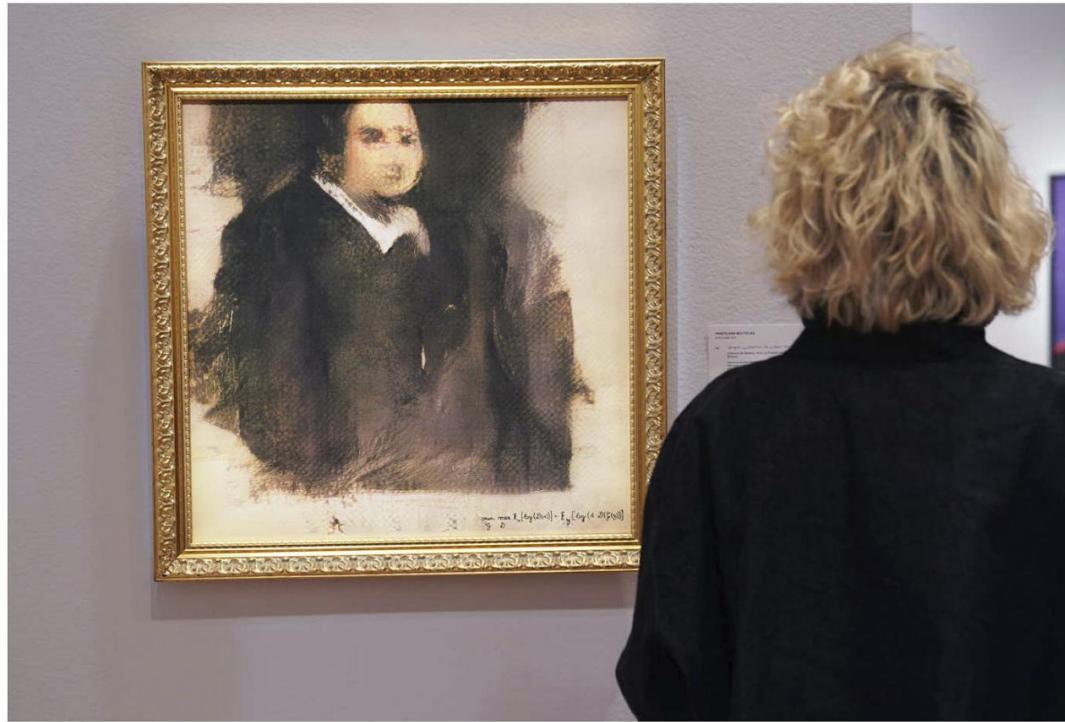
Find **hidden patterns** in the data

Map set of **input variables** to **output variable**

Generate options

An Artwork Made by Artificial Intelligence Just Sold for \$400,000. I Am Shocked, Confused, Appalled.

By Jerry Saltz  @jerrysaltz



Edmond de Belamy, from *La Famille de Belamy*. Photo: TIMOTHY A. CLARY/AFP/Getty Images



Last night Christie's did it again! The auction house sold an iffy object for an astronomical price.

Examples



INTRODUCTION

BASICS

APPLICATIONS

Go to:
<https://otoro.net/ml/netart/>

Go to:
<https://experiments.withgoogle.com/ai/drum-machine/view/>

How can AI help in Sustainable Building Design?

Where AI fits in the building lifecycle?

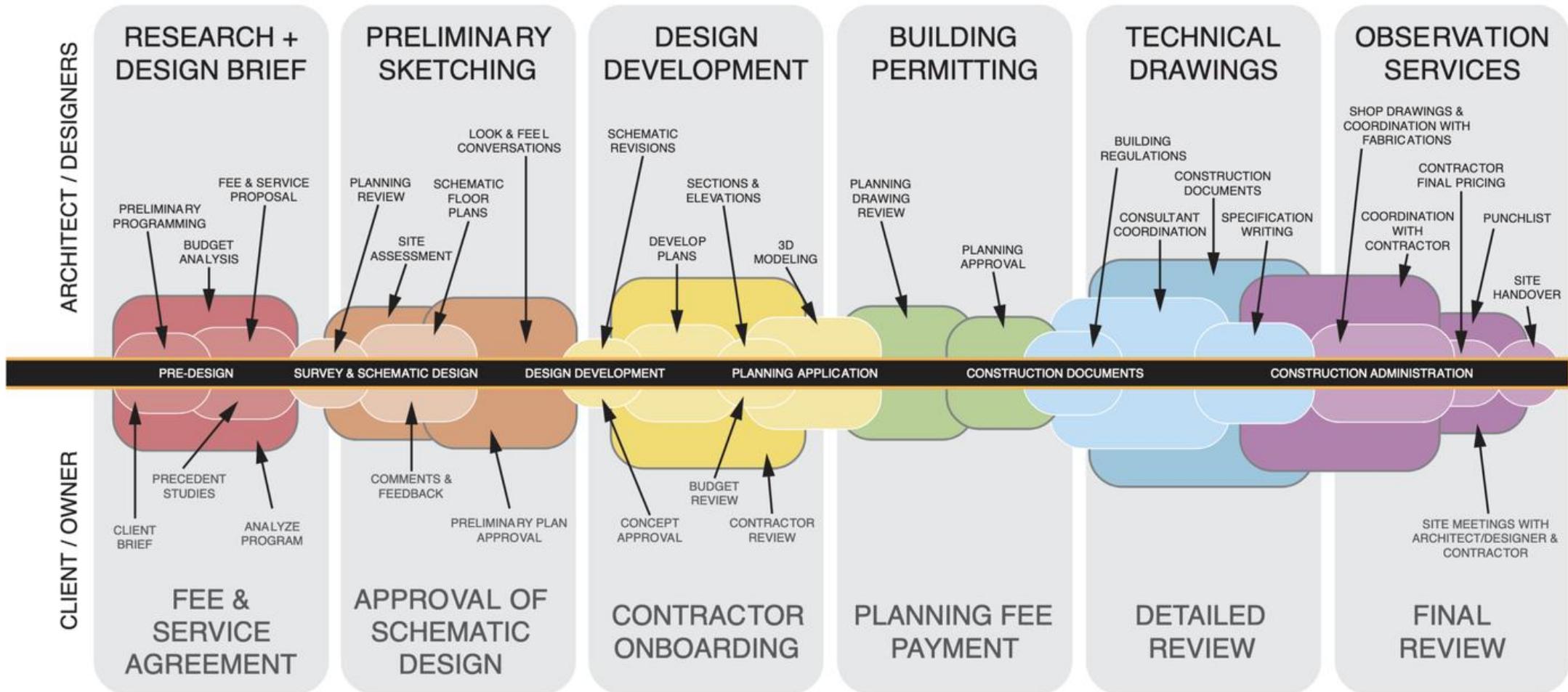


Image from Shahram Seififar



Autodesk Research Blog Publications Resources ▾ Research ▾ People ▾



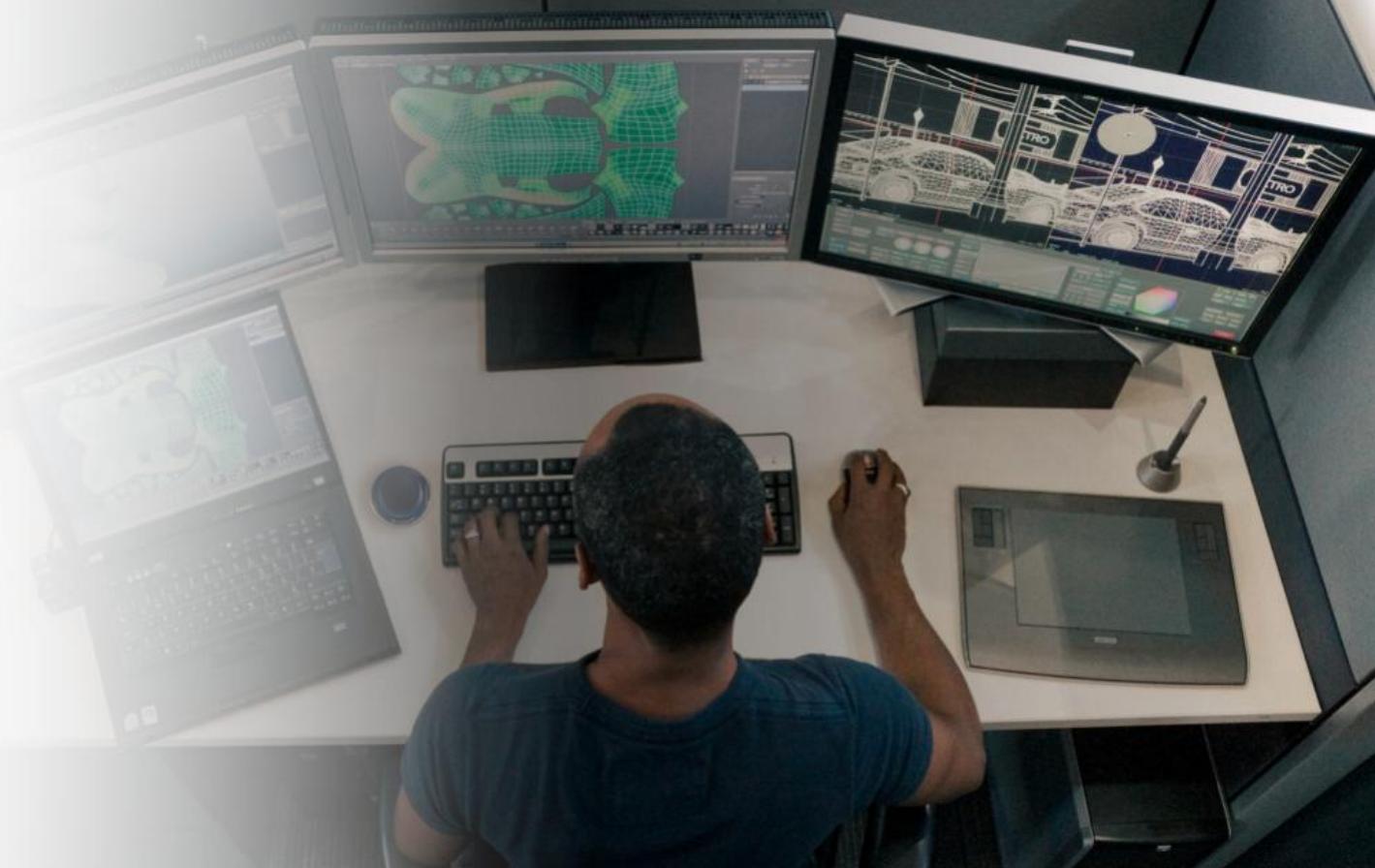
Contact us

PROJECT

Using AI to Optimize Construction Design

Architecture, Engineering, and Construction

Share page



INTRODUCTION

BASICS

APPLICATIONS

Examples – Improve Safety

The screenshot shows a software interface for managing construction safety. At the top, there's a header with the project name "Golden Gate Seaport Civic Center" and a user profile for "Jodie Fanganello". The left sidebar contains a navigation menu with links like "Insight", "Dashboards", "Risk", "Design", "Project Controls", "Quality", "Safety" (which is currently selected), "Commissioning", and "Safety & Quality Dash...".

The main area is titled "Safety" and includes several key components:

- Safety Risk Today:** Shows a large icon of a person with a hard hat and a red exclamation mark, labeled "High Risk Today".
- High Safety Risk Subcont...**: A section showing 3 of 24 high-risk subcontractors, with icons for Stern Structures, United Construction, and Delta Engineers.
- Safety Risk Factors:** A grid showing counts for different risk factors:
 - HIGH RISK SUBCONTRACTORS: 3
 - HIGH RISK ISSUES: 36
 - HOUSEKEEPING ISSUES: 10
 - POSITIVE OBSERVATIONS: 9
- Subcontractor Safety Risk:** A detailed heatmap table comparing subcontractors across various safety categories. The columns include:
 - Total
 - Fall
 - Struck By
 - Electrocution
 - Congest In Workplace
 - Fire
 - Other
 - Other
 - Personal Protective Equipment
 - Electrical
 - Crane
 - Spanning and Holes
 - Equipment/Tools
 - Fire Protection
 - Elevated Surface
 - Fall Arrest Systems
 - Risk Assessment
 - Site
 - Access and Egress
 - PPE - Gloves
 - Excavation
 - Hand Rail
 - PPE - Face and Eye
 - Guard Rail
 - Incidentous Material

INTRODUCTION

BASICS

APPLICATIONS

Examples – Regulatory Compliance

The screenshot shows a web-based AI chat interface. The top bar includes standard browser controls (back, forward, search) and a URL bar showing `dc-assistant.vercel.app/chat/DQyGzPP`. On the left, there's a sidebar with icons for file operations, a clock, and a star, followed by a "Chat History" section containing several previous messages. A "New Chat" button is also present. The main area starts with a user message: "What is the minimum road setback for a 12-storey Condominium Development, along a Category 2 Road?". The AI responds with: "For a 12-storey condominium development along a Category 2 road, the minimum road setback is 15 meters, which includes a 5-meter green buffer. For more detailed information, you can refer to the [URA guidelines on Building Setback from Boundary for Flats and Condominiums](#)". Below this, a "References:" section lists "[Flats and Condominiums: Building Setback from Boundary](#) (15 Feb 2023)". At the bottom, there's a message input field with placeholder text "Send a message." and a note: "Use this chat assistant for workloads classified Official (Open) only. Double check responses for mistakes."

What is the minimum road setback for a 12-storey Condominium Development, along a Category 2 Road?

For a 12-storey condominium development along a Category 2 road, the minimum road setback is 15 meters, which includes a 5-meter green buffer. For more detailed information, you can refer to the [URA guidelines on Building Setback from Boundary for Flats and Condominiums](#).

References:

[Flats and Condominiums: Building Setback from Boundary](#) (15 Feb 2023)

+ Send a message.

Use this chat assistant for workloads classified Official (Open) only.
Double check responses for mistakes.

Go to:
<https://education.github.com/pack>

Go to:
<https://github.com/City-Syntax/BPS5231>

Beyond Spaces

In-class activity

Choose a space in SDE, take a photo and change something you want



Go to:

<https://www.beautyplus.com/ai-replacer/upload>

Or

<https://www.phot.ai/object-replacer>

Or

<https://www.pxbee.com/ai-replace/>

Go to:
<https://bit.ly/BPS5231-L1-BeyondSpaces>

