Lecture 8:
Designing complex systems as interaction spaces

Case studies on applying theory to hard HCI problems

Overview of the course

- Theory driven approaches to HCI
- Design of visual displays
- Goal-oriented interaction
- Designing efficient systems
- Designing smart systems
- Designing meaningful systems (guest lecturer)
- Evaluating interactive system designs
- **Designing complex systems**

What are some things that make designs complex?

- How complex is the domain?
- How many different tasks might a user perform?
- How well defined are the outcomes? (Wicked problems, L3)
- How easy is it to understand each part?
- When the parts are put together how easy is to guess the behaviour?
- Does the system do things when the user isn't there? (Attention Investment from L3)

Designing tasks vs interaction spaces

Consider a (slightly silly) API for sending a message:

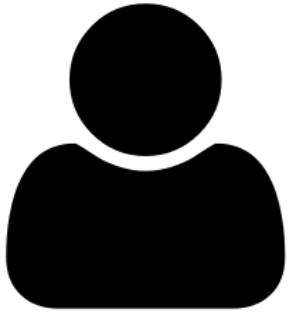
```
(1)  sendTheRightMessage()
(2)  sendMessage(Enum message)
(3)  sendMessage(String message, Urgency status)
```

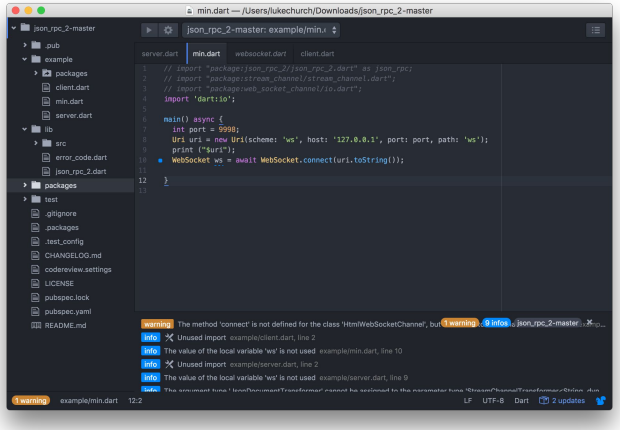
- Naive design would produce (1). Complex systems tend to be built out of reusable components that the users configure (2,3)
- Building this kind of system involves discussing tradeoffs as well as detailed design decisions
- This is the kind of interaction space that most of you will build: **Programming languages, APIs, AI systems**

Broad brush techniques

- Descriptions of specific actions result in a ‘death by detail’
- Don’t describe specific actions with an interface
  - Describe interaction with a level of *analytical distance* from the interface
  - Use an *analytical frame* which is a way of structuring a description of an interaction
  - The description can then be compared to an ideal for a domain to become a critical perspective (see Lecture 1)
- The right level of detail resembles an object-oriented design pattern, but for *human behaviour* rather than software.

Cognitive Dimensions of Notations (CDNs): Analytical Frame





A user

Performs an *activity*

Interface containing *notations,* described along a number of *dimensions*

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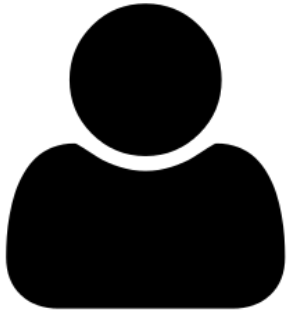

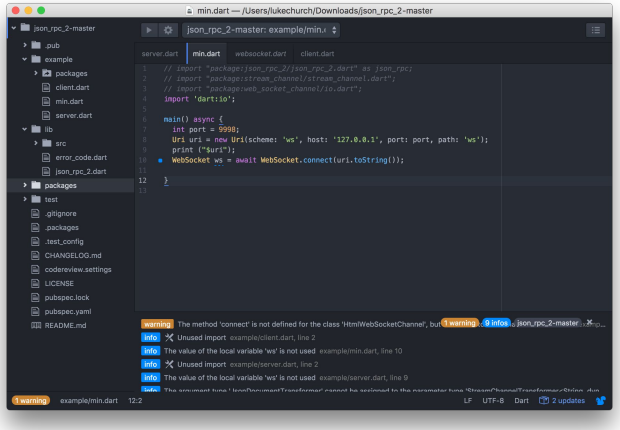

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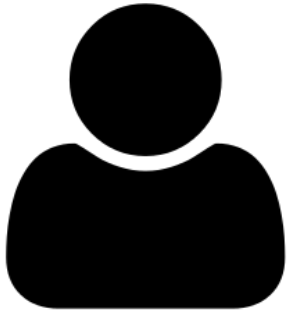
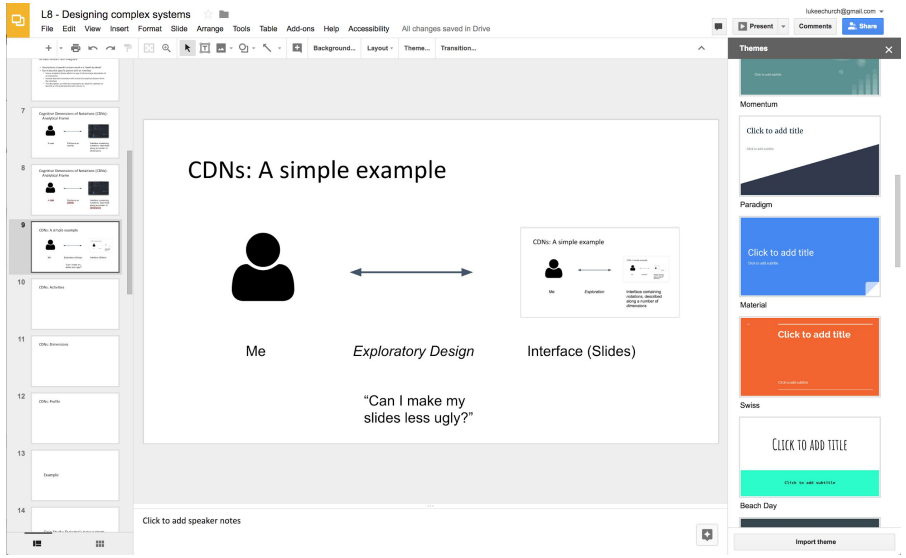
CDNs: A simple example





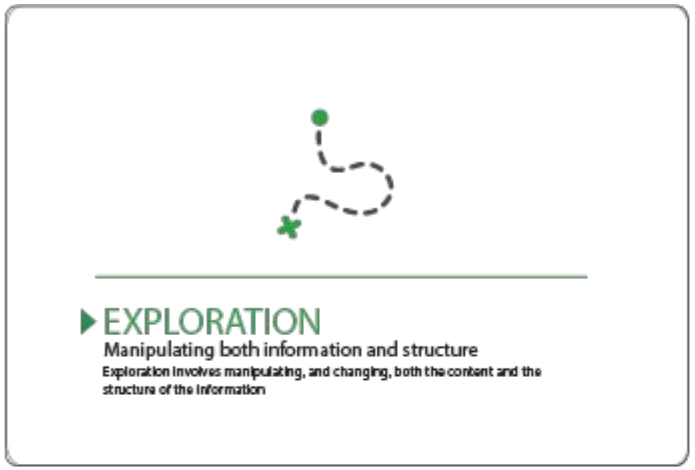
Me *Exploratory Design* Interface (Google Slides)

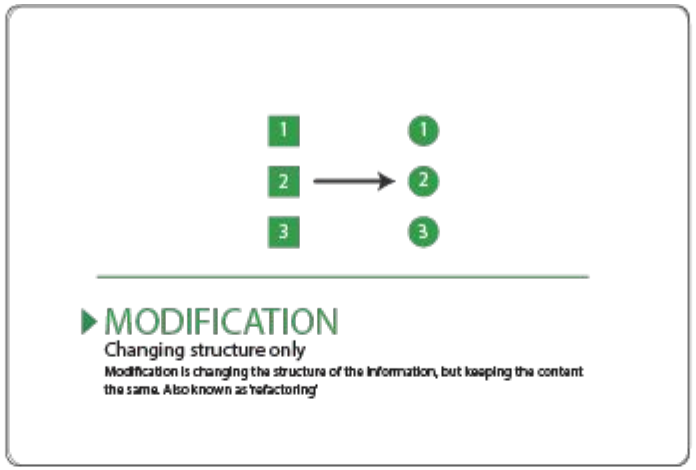
"Can I make my
slides less ugly?"

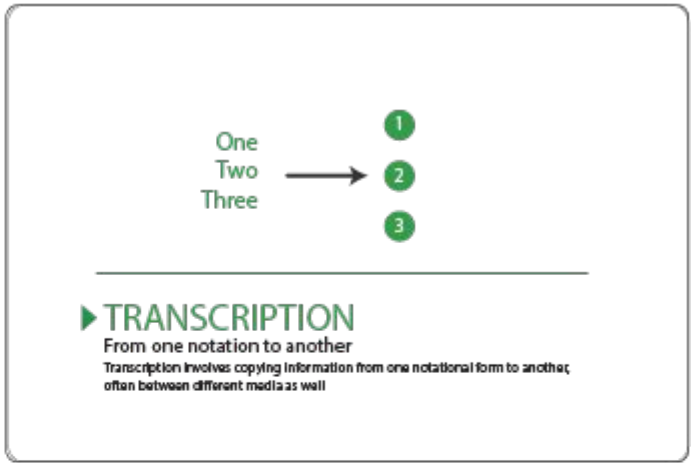
CDNs: A simple example (Demo)

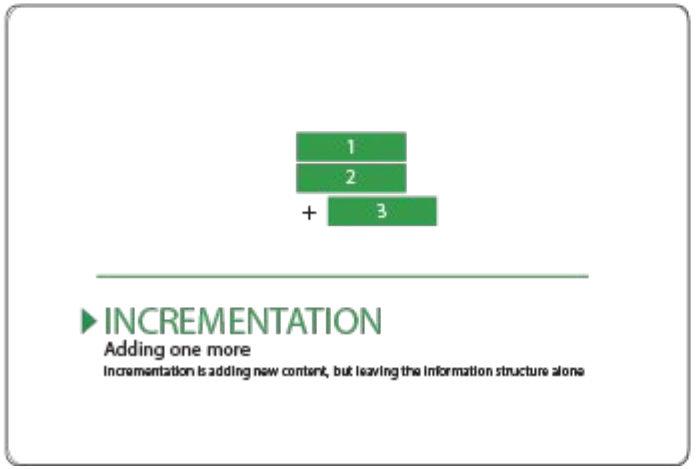
- One described change “Make the font of the headings Comic Sans”
  - Select the first slide, change the font
  - Select the second slide, change the font
  - Yawn.
- This is repetition *Viscosity*, many operations to perform one change
- Design maneuver: Introduce an *Abstraction* (master slide), decreases *Viscosity*, but increases *Premature Commitment*
- NB: CDNs analysis is meaningless independent of an interface.

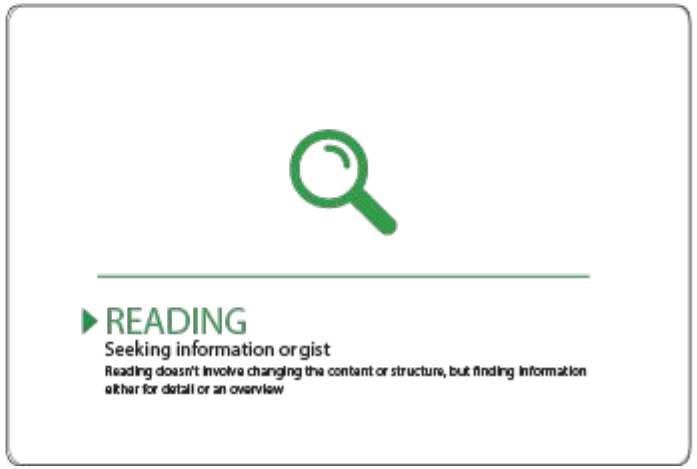
CDNs: Activities











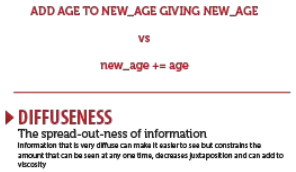
CDNs: Dimensions

ROLE EXPRESSIVENESS
How much elements suggest their purpose
Some syntax suggests its purpose better than others, this can help learning a system but is difficult to achieve without accepting the limitations of existing conventions

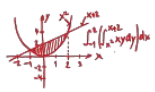
CONSISTENCY
Similar meanings, similar syntax
Internal consistency is important for understanding systems

PREMATURE COMMITMENT
Constraints on the order of decisions
Constraints on order often involve people having to make decisions before they would normally do in the course of solving a problem. This pre-thinking obstructs exploration, but can cause Useful Awkwardness

VISCOSITY
Resistance to change
One change in the mind becomes many operations in the interface. Viscosity is commonly exchanged for an abstraction.



DIFFUSENESS
The spread-out-ness of information
Information that is very diffuse can make it easier to see but constrains the amount that can be seen at any one time, decreases juxtaposition and can add to viscosity



USEFUL AWKARDNESS
Thinking hard is sometimes useful
Some notations cause the user to have to deeply consider their domain, which sometimes results in useful results. This is often caused by Premature Commitment.

ABSTRACTION
Mechanisms for generality
Abstractions support operations over multiple objects, or when the user isn't present
Abstractions provide support for efficient use, but may increase cognitive load, user perception of risk, and premature commitment

SYNOPSIE
Provides an understanding of the whole
Some notations provide a sense that you can step back and get a holistic impression, also described as the 'gestalt view'

HIDDEN DEPENDENCIES
Unexpected relationships
When one item is changed another, seemingly unconnected, item changes. Harmful to exploration. Commonly reduced by making the dependencies visible, at the expense of diffuseness and viscosity

HARD MENTAL OPERATIONS
Some things are just Hard
Some tasks that are known to be cognitively challenging, for example remembering lists of different possible branches

PROVISIONALITY
Degree of commitment to marks
High provisionality supports exploratory strategies such as playing 'what-if' games but can increase viscosity by expecting users to state when they are ready to 'commit' to their marks

LEGIBILITY
Readability of the notation
Various factors affect a notations readability such as how distinguishable its characters are and how well it supports perceptual parsing. Often trades off with diffuseness

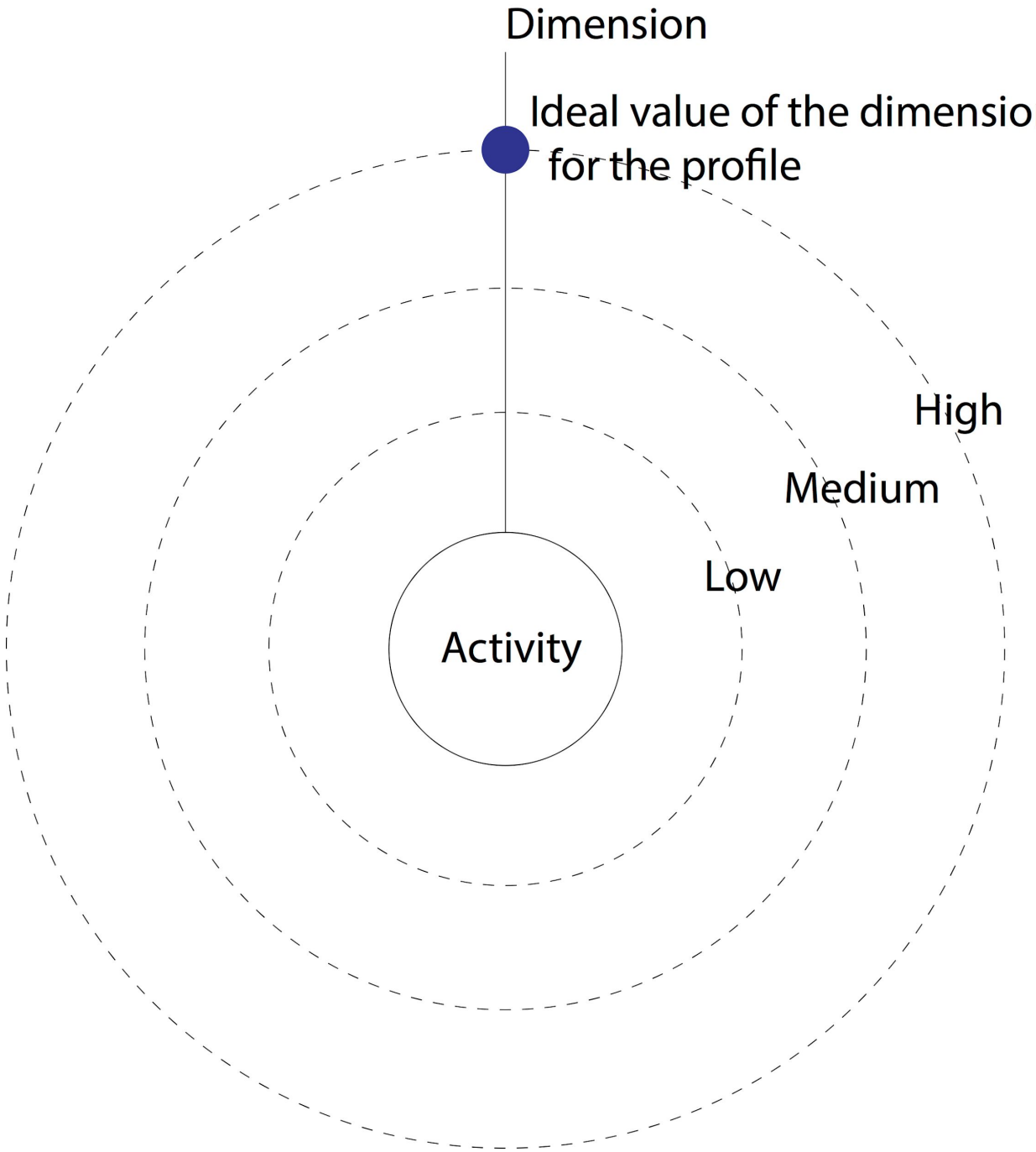
CLOSENESS OF MAPPING
Correspondence to the domain being expressed
A close relationship between the notation and the domain that it models makes implementation easier but may result in inflexibility and diffuseness

PROGRESSIVE EVALUATION
Feedback along the way
Progressive Evaluation describes how much the system displays partial progress towards a goal, or mandates the whole thing to be finished before any feedback is given.

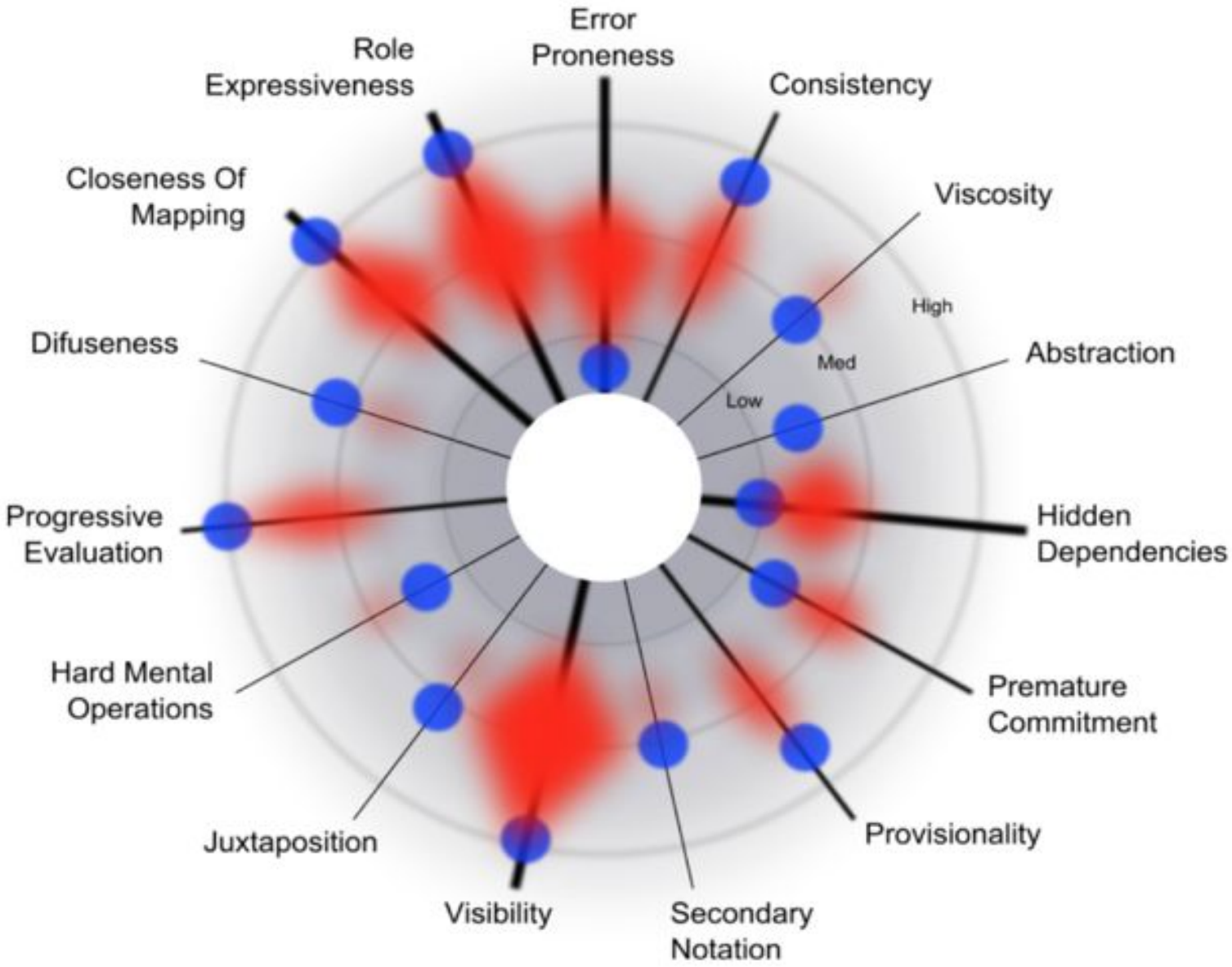
SECONDARY NOTATION
Escape from formality
Notation that is not formally interpreted. Comments, notes, layout etc.
Often omitted from computer based systems

JUXTAPOSITION
Simultaneous comparison
Simultaneous views of an information structure

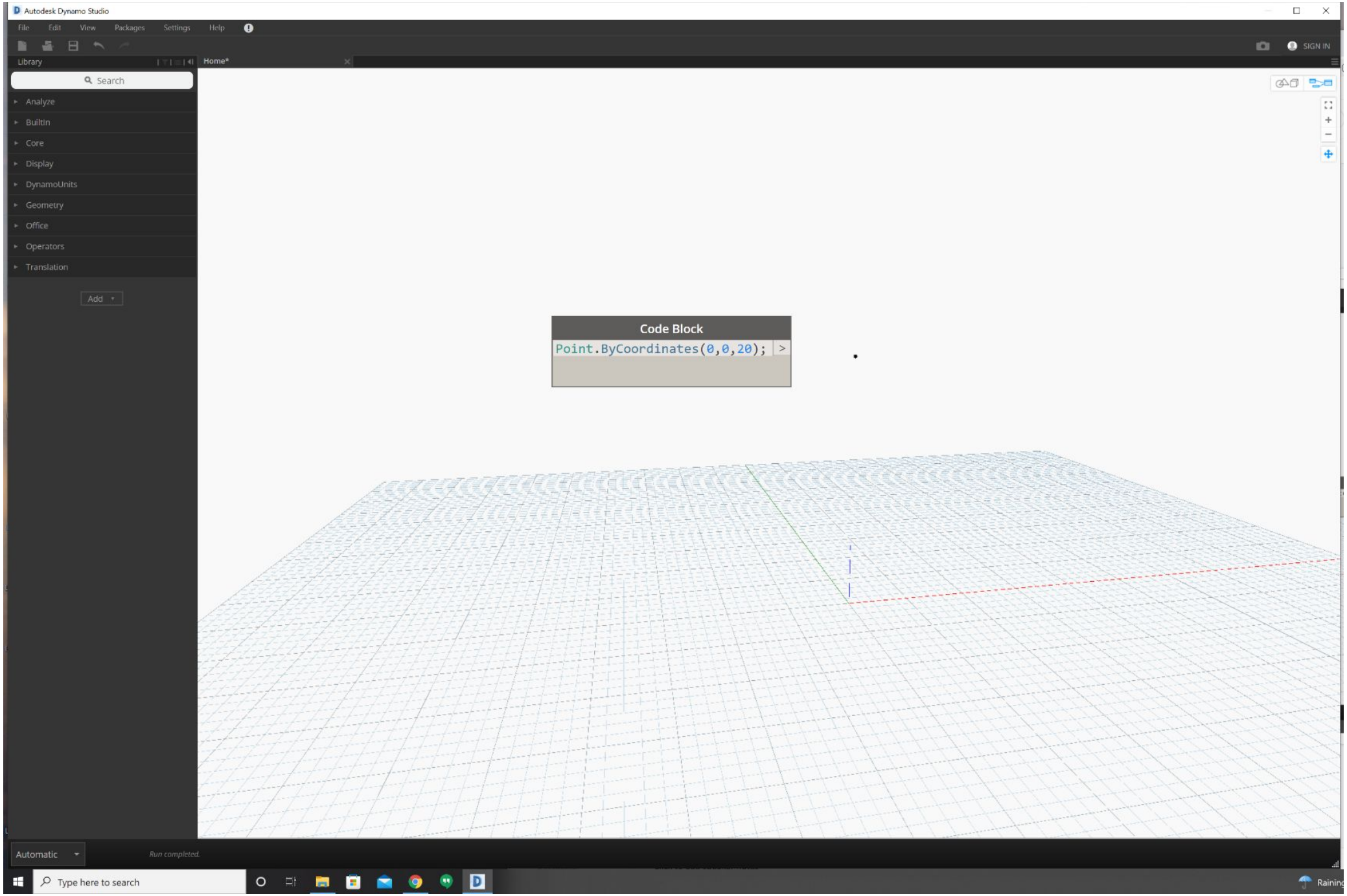
CDNs: Profile

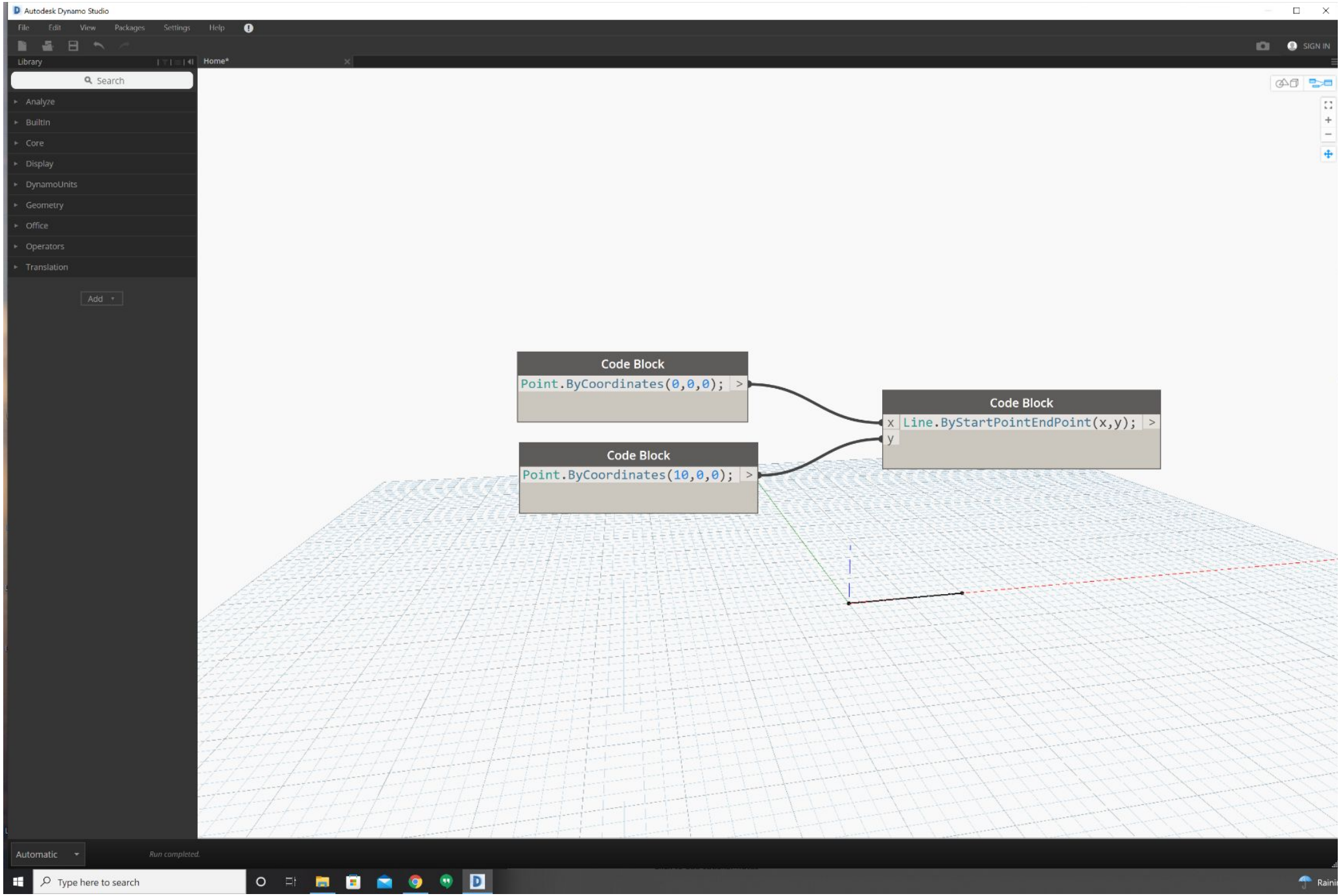


CDNs: Profile



Case Study: Dynamo’s type system


Autodesk Dynamo Studio
File
Edit
View
Packages
Settings
Help
SIGN IN
Library
Home*
Search
Analyze
BuiltIn
Core
Display
DynamoUnits
Geometry
Office
Operators
Translation
Add
Code Block
Point.ByCoordinates(0,0,20);
Automatic
Run completed.
Type here to search


Autodesk Dynamo Studio
File
Edit
View
Packages
Settings
Help
SIGN IN
Library
Search
Analyze
BuiltIn
Core
Display
DynamoUnits
Geometry
Office
Operators
Translation
Add
Home*
Code Block
Point.ByCoordinates(0,0,0);
Code Block
Point.ByCoordinates(10,0,0);
Code Block
x
y
Line.ByStartPointEndPoint(x,y);
Automatic
Run completed.
Type here to search

Dynamo

- Language for exploring building designs
- Includes a constructor **`Point(x, y, z)`** and array literal syntax [1,2]

Design question for discussion:

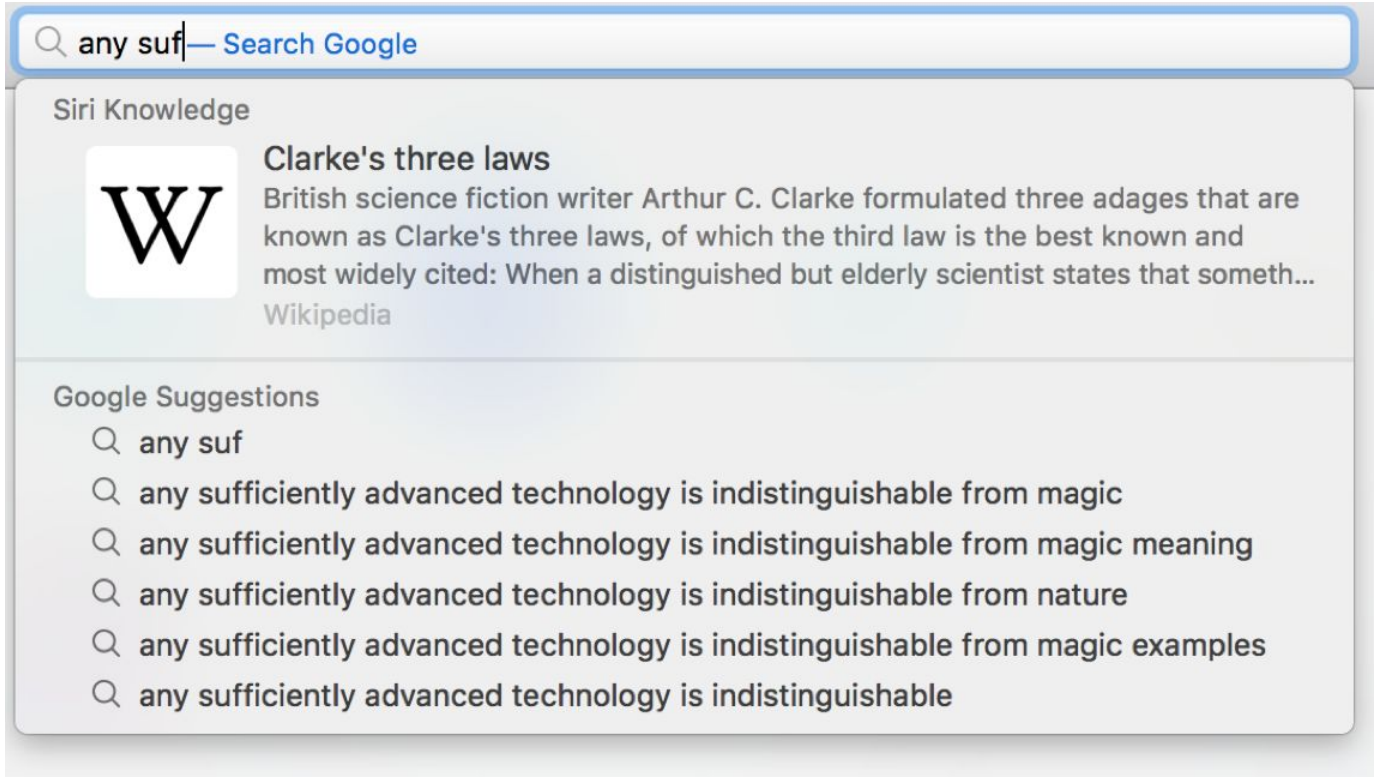
"What should **`Point([0, 1, 2], 10, 10)`** do?"

- What activities are important?
- How important: Viscosity? Premature commitment? Hidden Dependencies? Abstraction hunger?

Intelligent systems as interaction spaces

“Any sufficiently advanced technology will be indistinguishable from magic”

- Arthur C. Clarke, 1962



AI can feel like magic

Individual interactions with AI systems often seem quite trivial to perform, even if we don’t know how we go about doing them.

Because we don’t know how they work, if something goes wrong there’s no obvious way of intervening

(Personal images)

AI can be magic at a distance

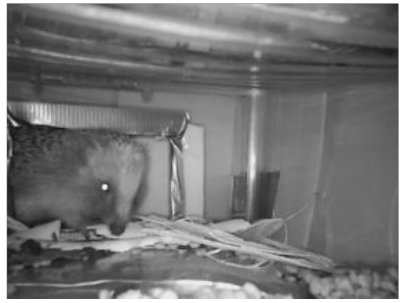
Having developed the capability to perform the task once, without human attention, we can now achieve results that would otherwise be impossible.

E.g. ‘find all the cats on the internet’

(images from Pexel, CC0)

AI can feel like magic at a distance

Applying the same technique to animal behaviour analysis



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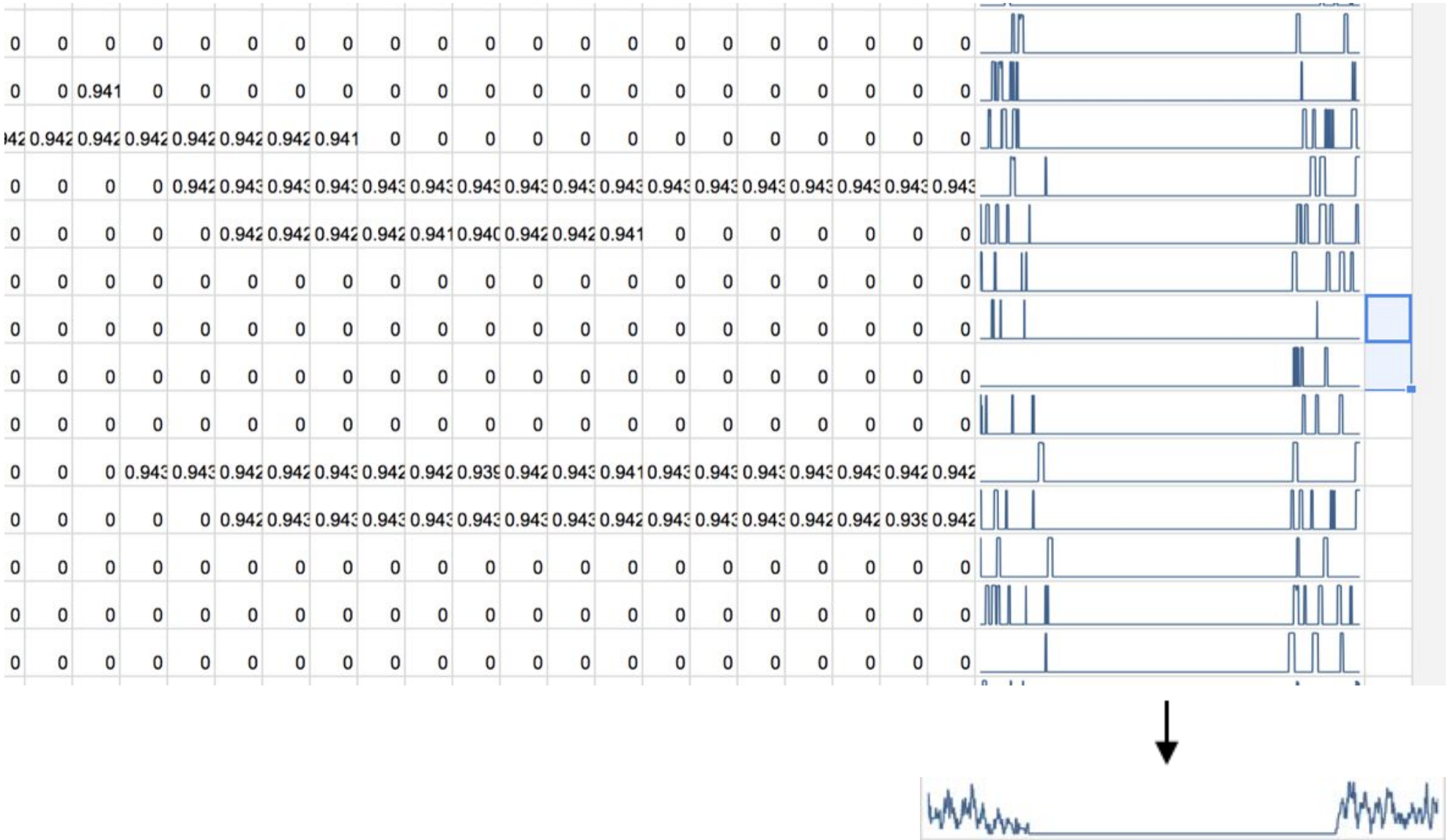
(Personal images)



How do you trust magic?
How do you control it?

If this was the result you saw - would you believe it?

From yesterday: there is a cat in this photo, where is it?

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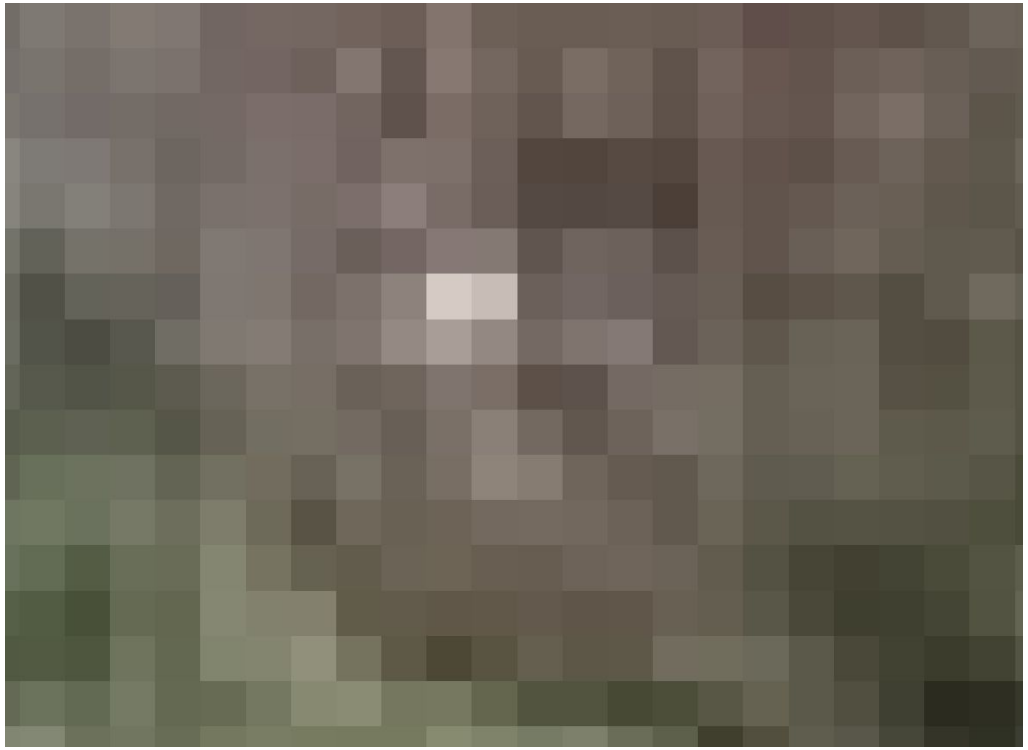

(Remember intersubjective readings of images from L2)

Somewhere in this picture there is a cat. Where is it?

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Analysis

That is a very well-camouflaged cat! If you look at the **wooden railing** on the far left of the deck, the cat is sitting just behind it, looking toward the camera.

Where to look:

- Follow the **left-side railing** down towards the stairs.
- Look through the **vertical slats** (balusters) about halfway down that section.
- You can see the cat's face and ears peeking through the gap between two slats.

It blends in almost perfectly with the brown, leafy ground in the background!

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Sure, please!

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Sure, please!

This is what the cat in question actually looks like

How do you trust magic?

A simple example of programming with ML

- Research in 2011 by Sumit Gulwani at Microsoft Research
- “Synthesises a program from input-output examples”
  - How do you choose the examples? (Premature commitment?)
  - How do you know what will happen? (Progressive evaluation?)

- Now Excel FlashFill
  - Paste a list of semi-structured text data into the left column
  - Type an example transform result in top cell to the right, then <Enter>
  - Press <Ctrl+E>

Conversational agents (incl. ChatGPT)

- Do they build a user model, goal model or task model?
- Will this be more or less complex than FlashFill?
- How can you see that model?
  - i.e. what is the notation - will it be Python?
- How could you modify the model?
  - … in response to errors (yours, or the system's)
  - … if you change your goals?
- Is it healthy to have a friend without a body?
  - The "Her" problem
- Why are investors spending billions?
  - Resignations over addiction / the "AdWords" problem

Amazon Echo / Alexa agent

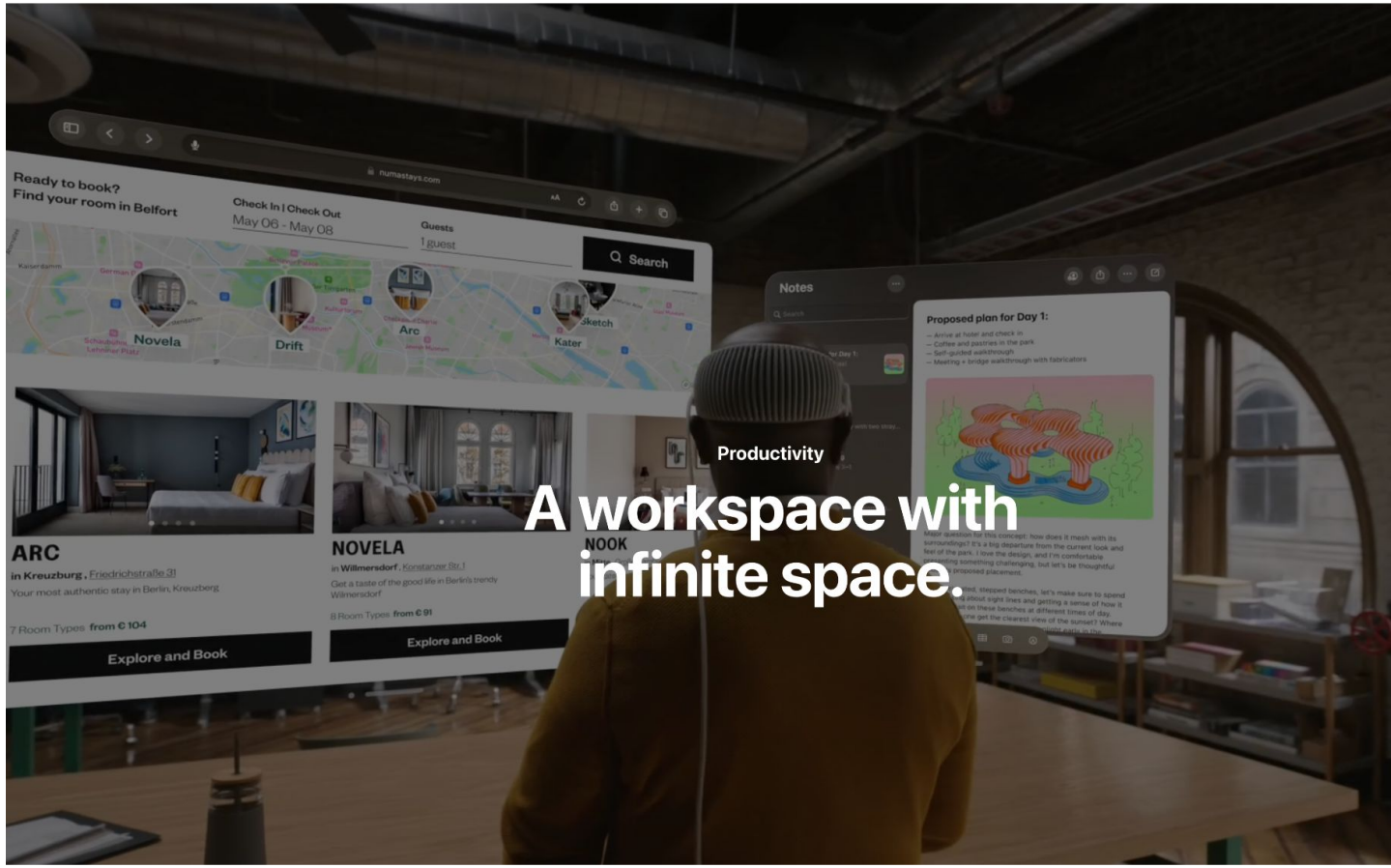
Human issues in machine learning

- Ethics and accountability
  - automating and/or justifying bias and prejudice
  - can your trust explanations (sycophancy + hallucination)
- Reward for labour
  - who did the intellectual work in training data and moderation?
  - how are they paid, and where do the profits go?
  - Spotify, Audible and TicketMaster could still get worse
- Human meaning
  - where do people find meaning (guest lecture)
  - digital humanities for critique of text, images, art
  - creative expression is as much 3rd wave HCI as consumption

Some [other] current research problems

VR and AR (XR) still use visual correspondence

Microsoft Hololens



Apple Vision Pro

The Metaverse!

Programming, or direct manipulation?

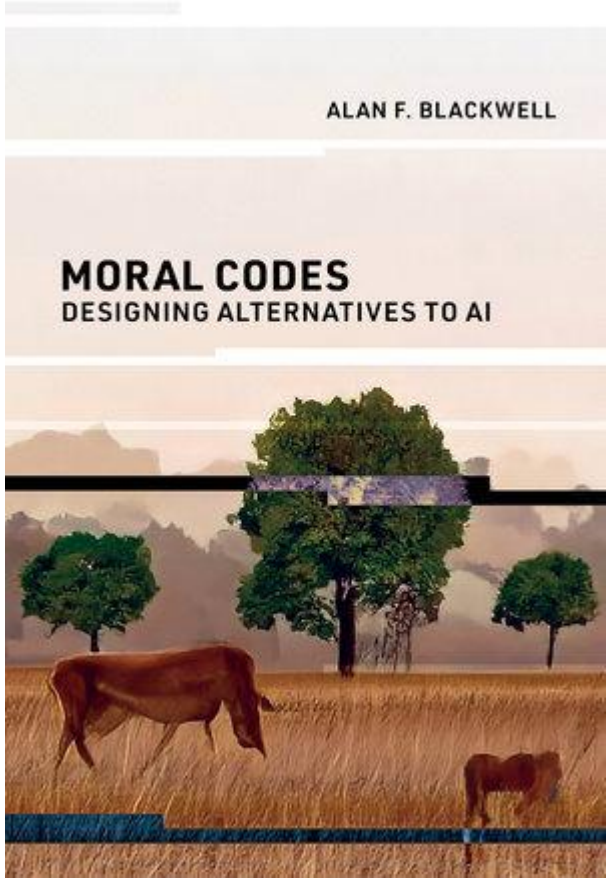
- Many Internet of Things (IoT) devices have physical switches etc
  - But how do you define configuration, policy, future action?
  - Now we need a notation - or a programming language
- Remember behavioural economics and attention investment
  - Even around your house, bounded rationality happens

Philips Hue Light control

Global challenges

- Is knowledge infrastructure built to ...
  - … prioritise low income populations
  - … advance Sustainable Development Goals (human rights, education etc)?

Further interest...

- Part II / Part III Projects in
  - Human-Centred AI (Alan's Critical Design Studio)
  - Human-Robot Interaction (Gunes)
  - Deceptive design and dark patterns (Seaborn)
  - Computer music (Alan + CMS)
  - Visualisation (Wischik)
- Other Cambridge MPhil options
  - Digital Humanities
  - CHIA ("Centre for Human-Inspired AI")
  - Ethics of AI, Data and Algorithms

- Alan's book describes many of these connections