1st Colloquium on AI4AEC

As-Is Information

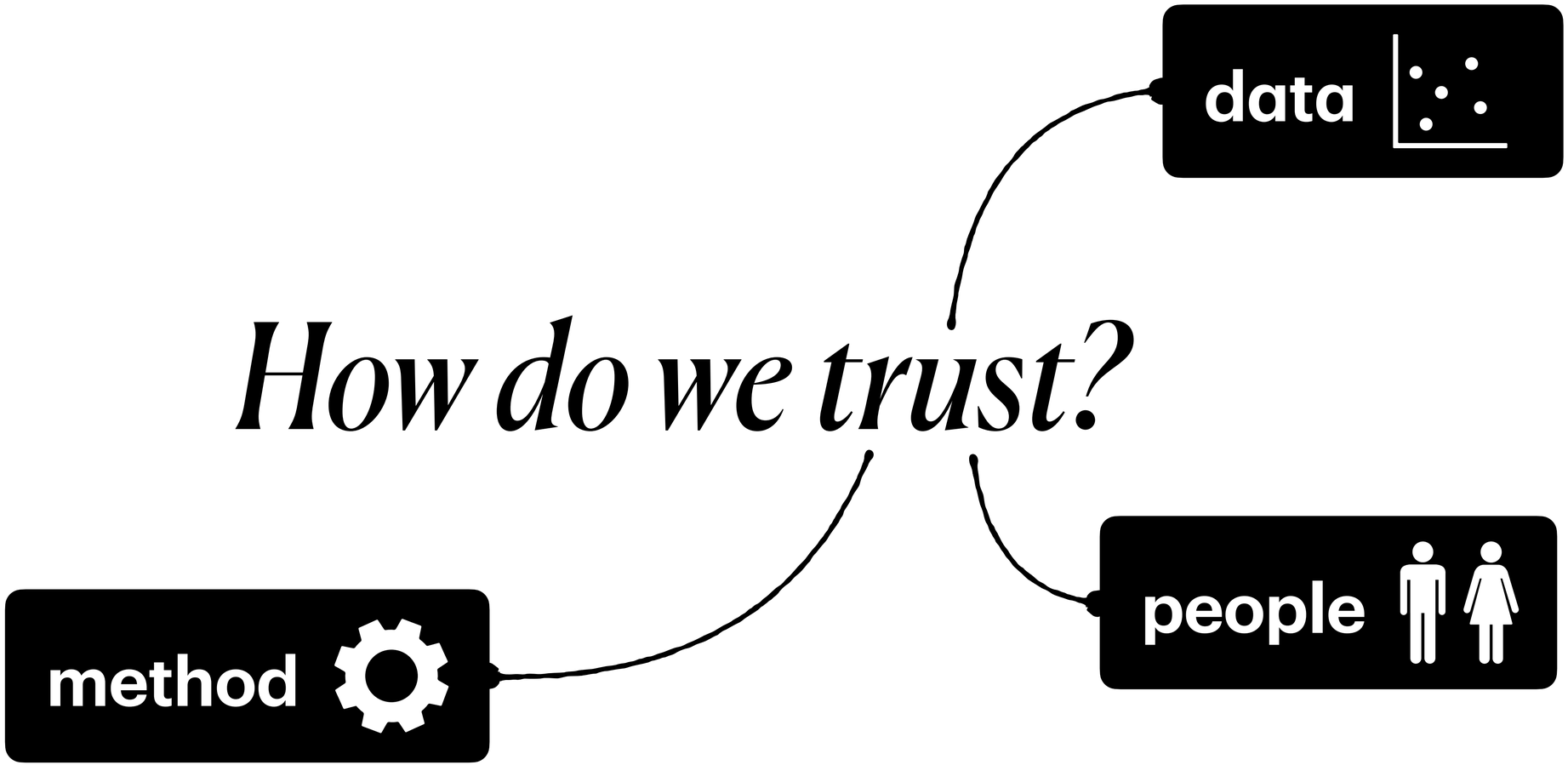
It’s all about trust.

Iro Armeni | Andrew Cameron

Aug 20th 2020 | Stanford University

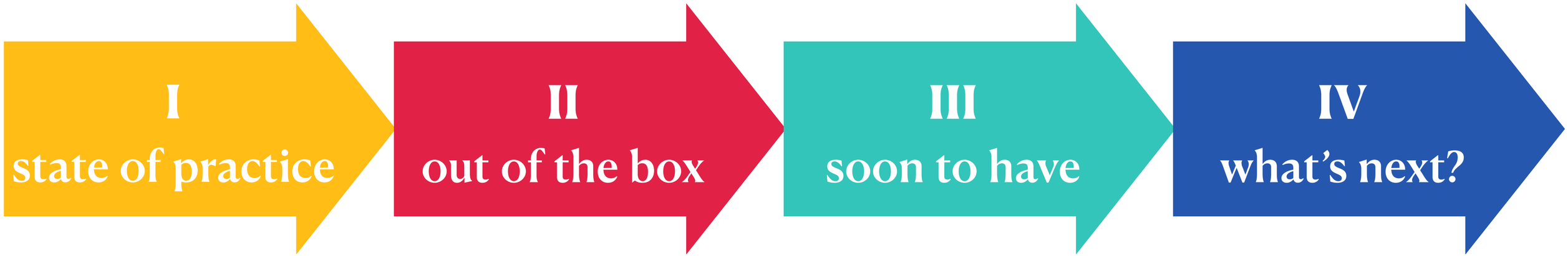
We cannot do anything without good information

And it’s hard to get!


data
How do we trust?
people
method

Construction Progress Management

Agenda



State of Practice

Example: Schedule Review

Task:

- Determine if scheduled activities have been completed, and if not, update schedule
- Relies on image data

Data Collection:

- Weekly Progress Pictures *(contractually obligated)*
- Field Walks

State of Practice

Can Become Manual “Guesswork"

How is the task performed?

- Manual check for binary answers

  e.g., Are air ducts installed?

- Lacks quantification and prediction capabilities

- Decision making is not supported by structured as-is information but frequently by the engineer’s experience/gut feeling

  e.g., Why are we doing schedule updates/changes?

- Affects multiple CPM workflows

  e.g., scheduling flow is based on path of least resistance than the correct work sequence

Effective CPM

And how it affects human relationships

- **Timely & accurate** feedback can be a catalyst in effective team *communication*
- **Good data** leads to *educated* conversations and minimizes points of friction
- A **single source of truth** establishes *credibility* among stakeholders
- Truth should be **objective and straightforward to prove**, and never a by-product of the amount of data in one party's hands

Evaluation Criteria of Process

Currently

Project Cost

Project Duration

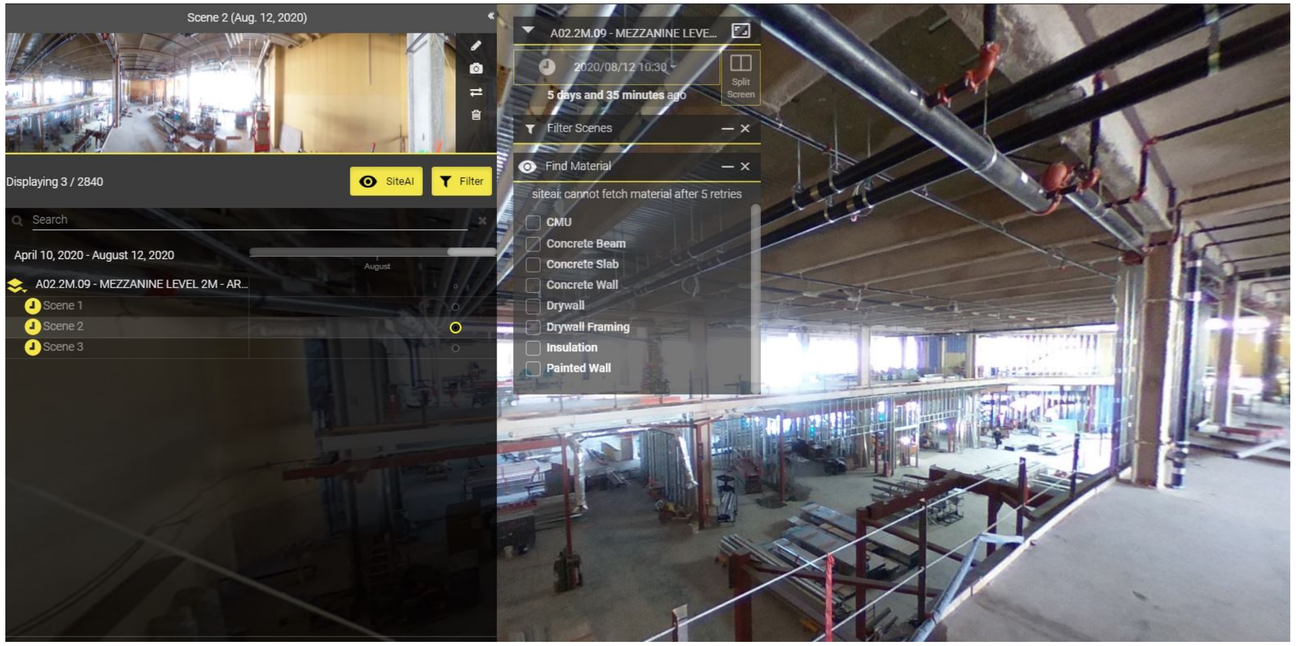
Stakeholder satisfaction

# of quality inspections approved

(less frequent)

Out of the box

Filtering of Visual Data using AI



- Panoramic Images or Movies
- Weekly Capture
- Interface that organizes visual data per point in time
- Equipped with recognition software to sort through images
- Available for certain elements/materials

Out of the box

Doesn't change WHAT we are doing but HOW we are doing it

How is the task improved?

- Narrows down the time range you would be looking for this information
- Faster access to information and with less effort

Out of the box

Limitations

- Still a predominantly manual task
- Relies on the industry expert’s decision making skills
- No tangible information provided by the AI tool but a faster answer to some of the possible binary questions a practitioner would ask
- Lacks quantification and prediction capabilities

Bad results can
disturb confidence to the
single source of truth

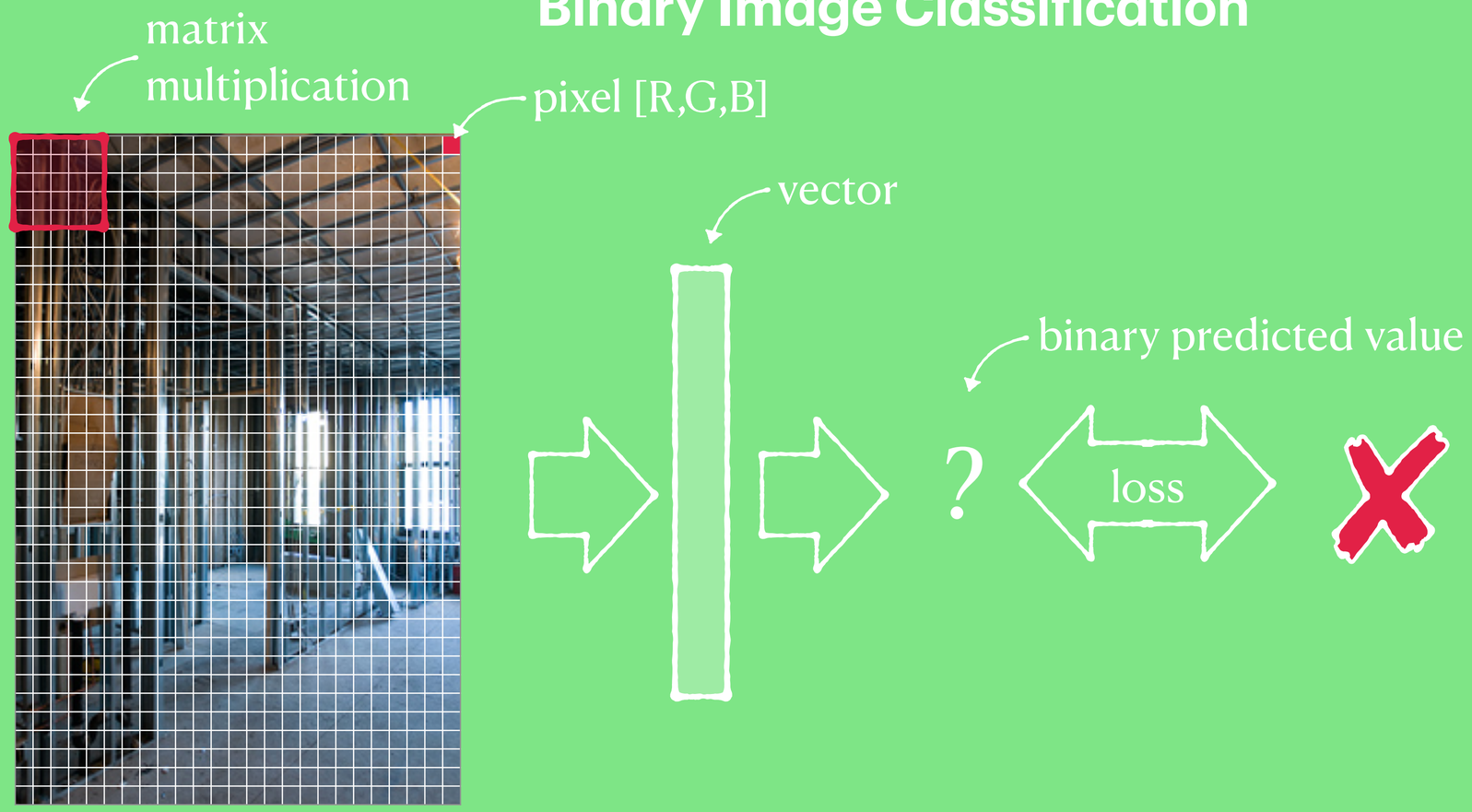
Out of the box

Technology under the hood

question input output

Out of the box

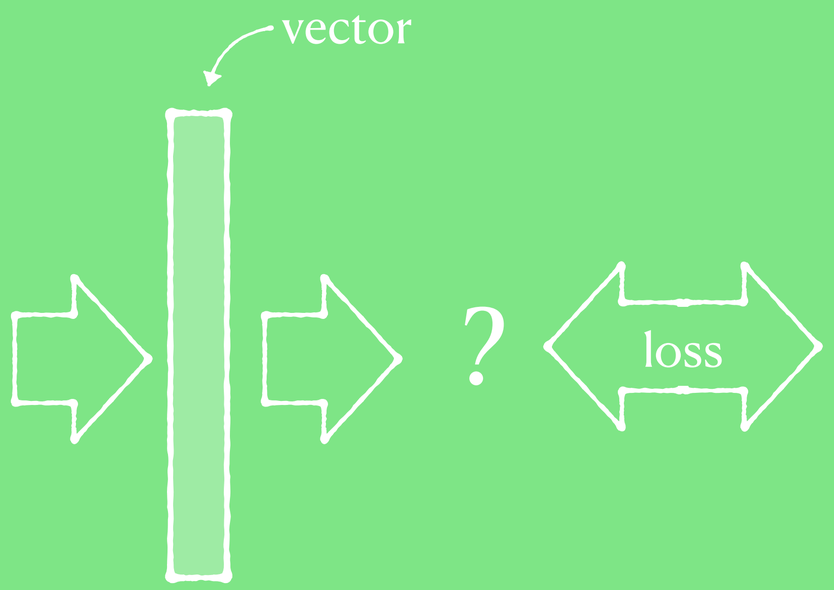
Binary Image Classification



input representation

Out of the box

Multiclass Image Classification



air duct

truss

door

stud

...

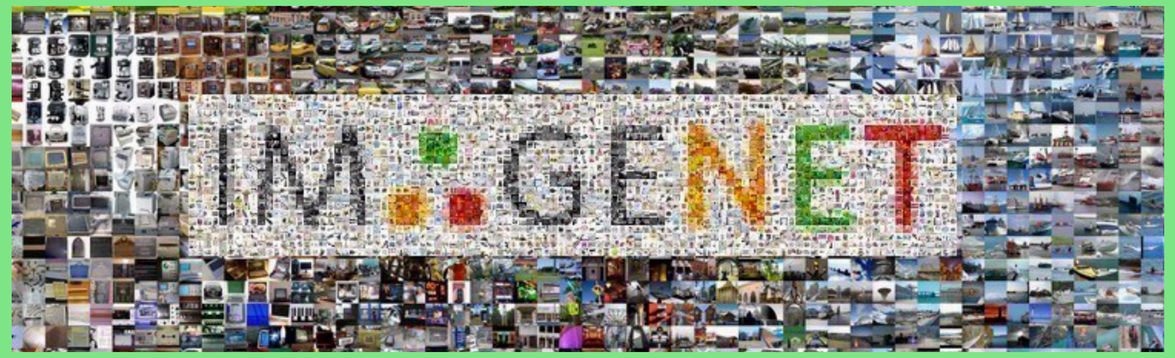
input

representation

ImageNet & AlexNet

The catalysts for image classification: data & then method

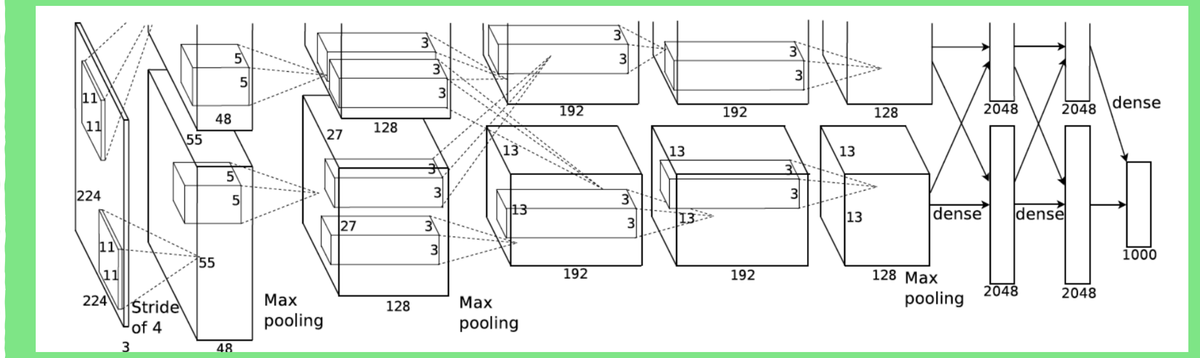
ImageNet [1]



14,197,122 images with image-level labels

Leveraged in different visual understanding tasks to provide initial understanding

AlexNet [2]



Convolutional Neural Network

Leveraged in different visual understanding tasks and architectures

[1]. Deng, Jia, et al. "Imagenet: A large-scale hierarchical image database." CVPR 2009

[2] Krizhevsky, A., et al. "Imagenet classification with deep convolutional neural networks.", NeurIPS 2012

Confidence

Machine vs User

AI

Where is the threshold?

0.7

0.721

question

input

output

What makes this AI fail?

And we should build mechanisms to address it

input data

Reflections, lighting, occlusions, blurriness, etc.

training dataset

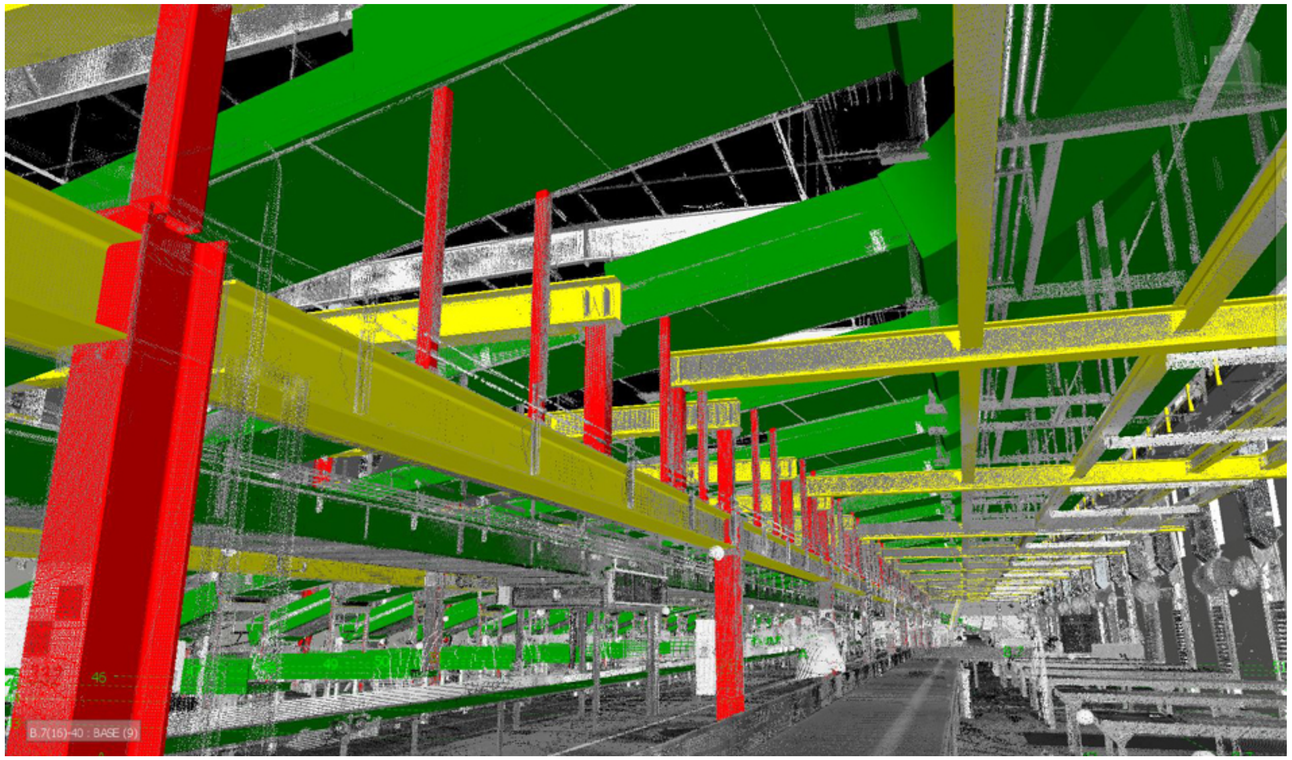
Unbiased dataset that generalizes *(the world is so different and diverse)*

method

Outlier cases that the method does not know how to solve but tries anyways

Soon to have

Quantifying As-Is Conditions via Comparison of Visual Data



- 3D Point Clouds (from laser scans or images)
- Compare as-built conditions back to the federated building model
- Ability to export quantity, location, tolerance, and size
- Quantities and changes over time

Soon to have

Going from a **GUIDE** to answers to **ACTIONABLE INFORMATION**

How is the task improved?

- Automated quantification of built units
- Faster issue identification and resolution, with less effort

Soon to have

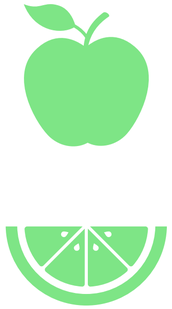
Limitations

- Model that is designed the way builders would install
- Job site is constantly evolving *(e.g., access to areas, installation, weather conditions)*
- Clash check requires humans to inspect and identify **why** it is happening *(causal effect is not established)*
- Requires more effort in collecting the data

Are we taking the output of the system as granted to be ***correct***?

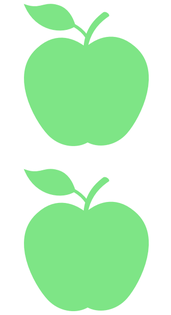
Soon to have

Technology under the hood



Scan vs BIM

- compare point cloud with BIM
- locally check around the BIM object and decide if it exists in the point cloud



Scan 2 BIM

- visually recognize elements from scratch creating a new BIM
- compare BIM against BIM

Limitations

No underlying understanding of the scene

- What happens if the model doesn’t have enough details?
- What if it labels something as something else because it ‘looks’ alike?
  (simple non-cluttered scenes vs real-world)
- Registration of comparison data in the same coordinate system is not trivial.

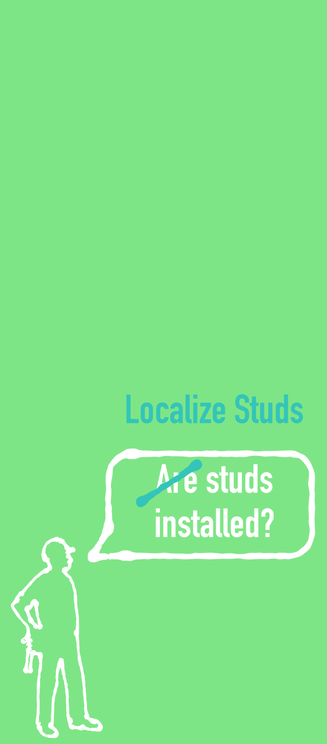
Scan 2BIM

Technology under the hood

question input output

2D Visual Data Segmentation

similar operations but in 3D



question

input

output

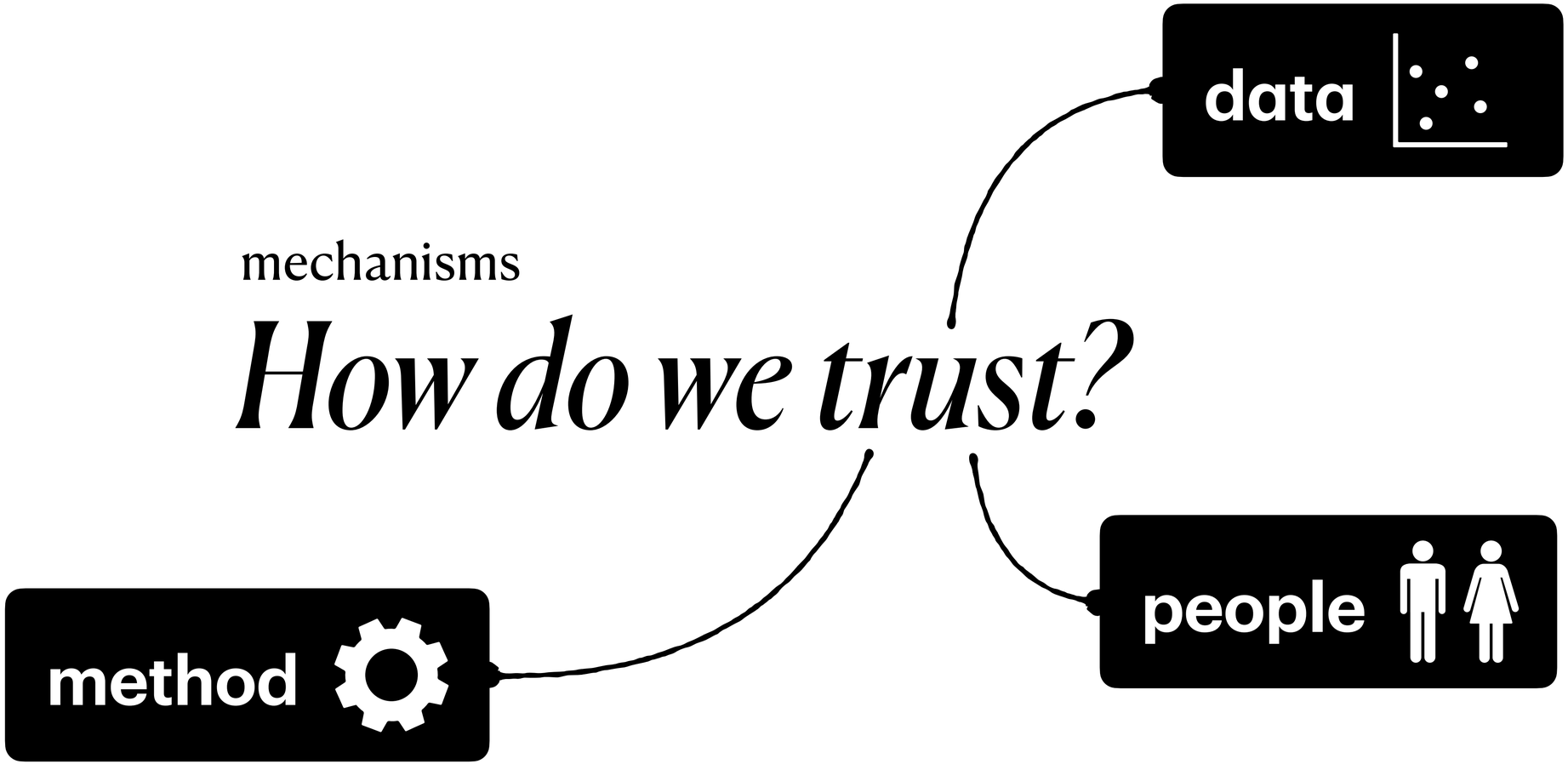
From State-of-Practice to Soon-to-Have

A summary

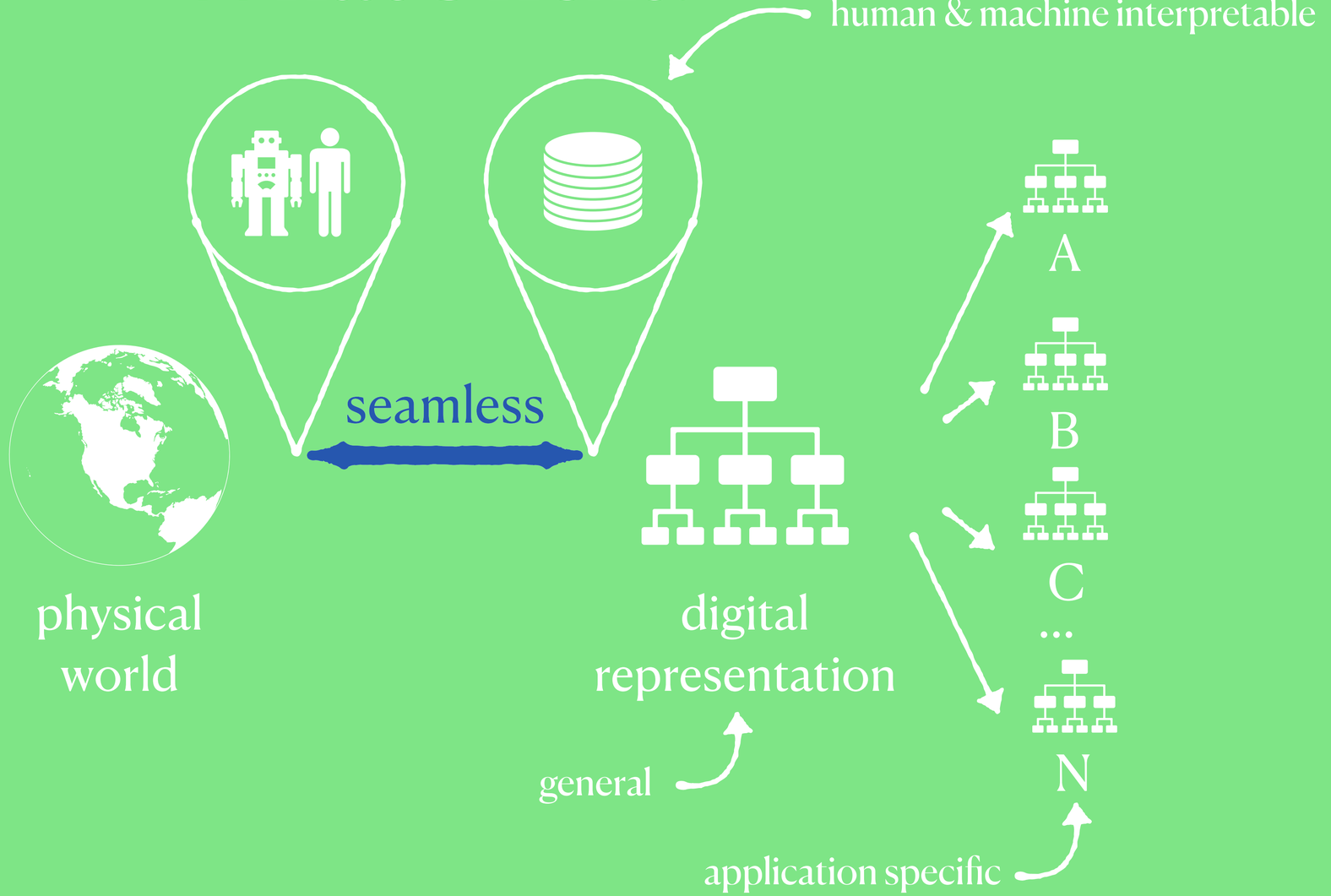
	State of Practice	Out of the Box	Soon to Have
Data	Images	Images	3D Point Clouds
Process	**Manually** shifting through images to determine binary questions	**Automatic**: Determines which images contain certain materials	**Automatic**: Comparing as-built conditions back to the design
Output	Verification of e.g are ducts installed?	Verification of e.g are ducts installed?	Quantification, localization, etc.
Quantitifiable	No	No	**Yes**
Predictions	**No**	**No**	**No**

mechanisms

How do we trust?



What's next?


human & machine interpretable
seamless
physical world
digital representation
general
A
B
C
...
N
application specific

What's next?

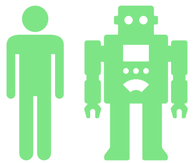
Data and Method

data & method

- incorporate noise and uncertainty in the prediction process
- built-in mechanisms for not taking action

What's next?

Human-Machine Interaction

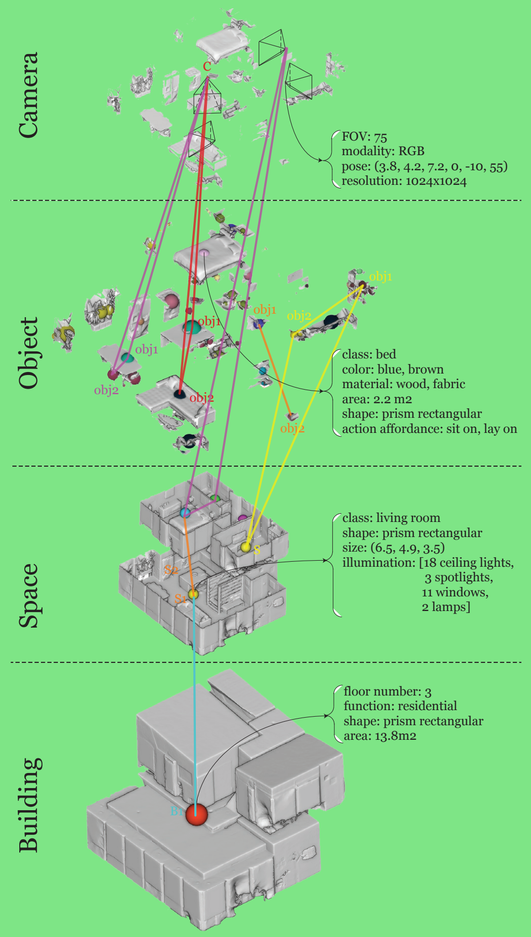


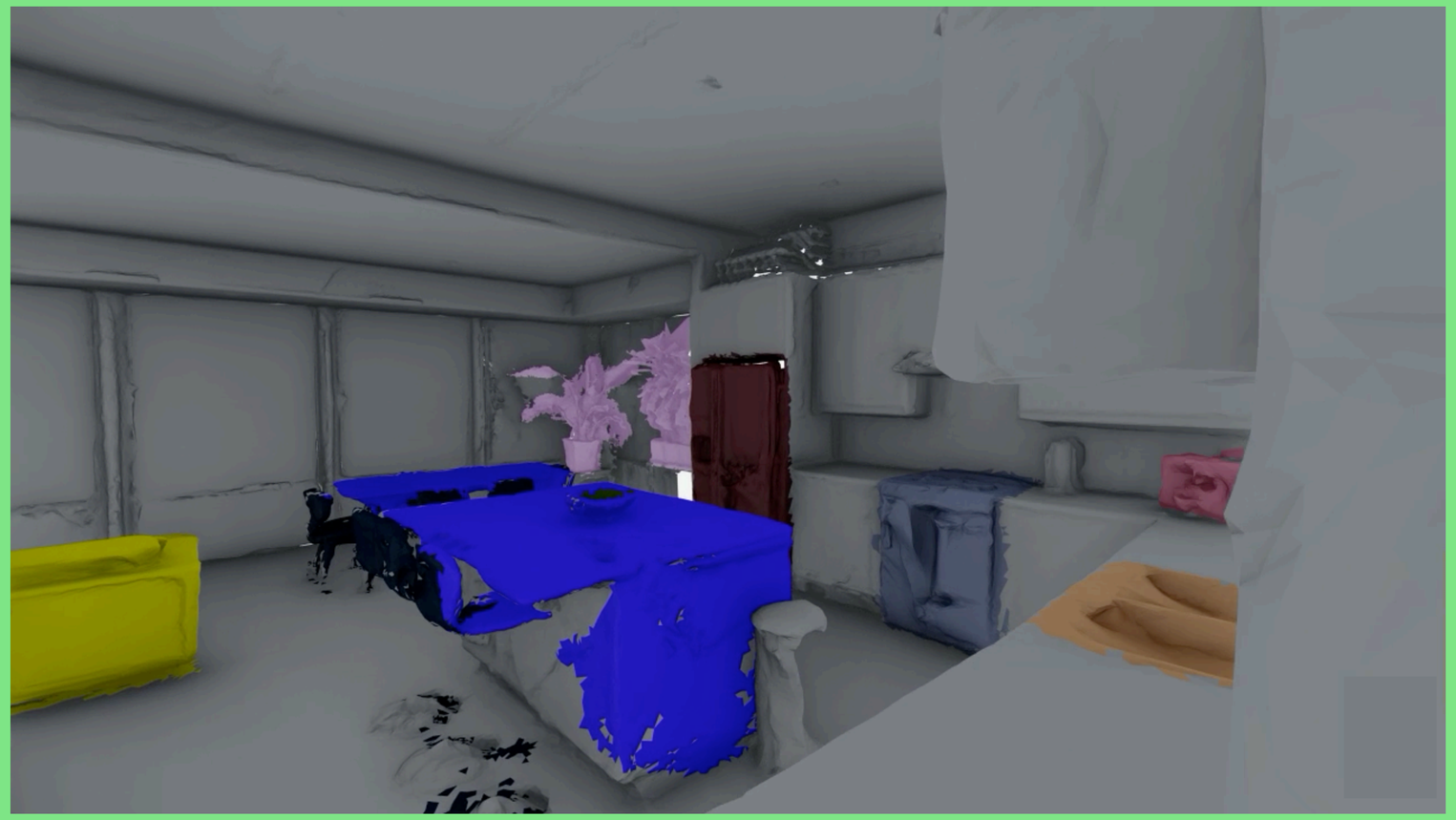
User & Machine

- learn from user input (constant learning)
- understand where user input is needed
- will we ever remove human from the loop?

What's next?

Structured Information





Armeni, Iro, et al. "3D Scene Graph: A unified structure for semantics, 3D, and camera." ICCV 2019

Effective CPM

And how it affects human relationships

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- **Good data** leads to *educated* conversations and minimizes points of friction
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