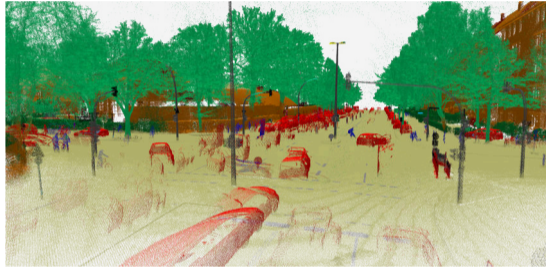


# Geospatial Data - The Perfect Food for AI

Where2B Conference, Dec. 12, 2019



**Prof. Dr. Jürgen Döllner**

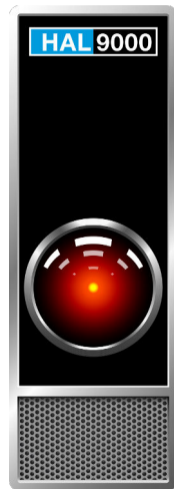
Hasso-Plattner-Institut, Digital Engineering Fakultät, Universität Potsdam  
Hasso Plattner Institute, Hudson Yards, NYC  
GraphicsVision.AI, Malaga

- About AI
- AI for 3D Point Clouds
- AI for Location Intelligence
- Conclusions

# About AI

## Famous AI Characters

- HAL 9000: “Heuristically Programmed ALgorithmic Computer” in “2001: A Space Odyssey”.



## Famous AI Characters

- ELIZA, the famous first chatbot in computer science
- Built by Josef Weizenbaum in 1966
- A speech-based simulation of a psychologist's interaction with a patient

```
ELIZA: Is something troubling you ?
YOU:  life is meaningless
ELIZA: Do you feel strongly about discussing such things ?
YOU:  everyone is born, grows and dies
ELIZA: Who, for example?
YOU:  you
ELIZA: You're not really talking about me -- are you ?
YOU:  me
ELIZA: That is interesting. Please continue.
YOU:  what is the purpose of suces and happiness
ELIZA: Are such questions much on your mind ?
YOU:  all the time
ELIZA: Tell me more about that.
YOU:  why should i study
ELIZA: That's quite interesting.
YOU:  i cant take my knowledge with me
ELIZA: Is it important to you that your knowledge with you ?
YOU:  i cant take anything with me
ELIZA: Have you tried ?
YOU:  i'll have to die for that
ELIZA: Can you elaborate on that ?
YOU:  █
```

## What is intelligence?

- Human intelligence
- Natural intelligence
- Artificial intelligence
- General-purpose intelligence
- Dark side of intelligence
- ...

*“AI is going to amplify human intelligence not replace it, the same way any tool amplifies our abilities.”*

(Yann LeCun, Turing Award 2018)

*Artificial Intelligence (AI) is changing the way IT solutions are designed, built and operated, whereby AI is not being limited to specific application areas—it is currently finding its way into all industries.*

(HPI, AI Lab for IT Systems Engineering, 2019)

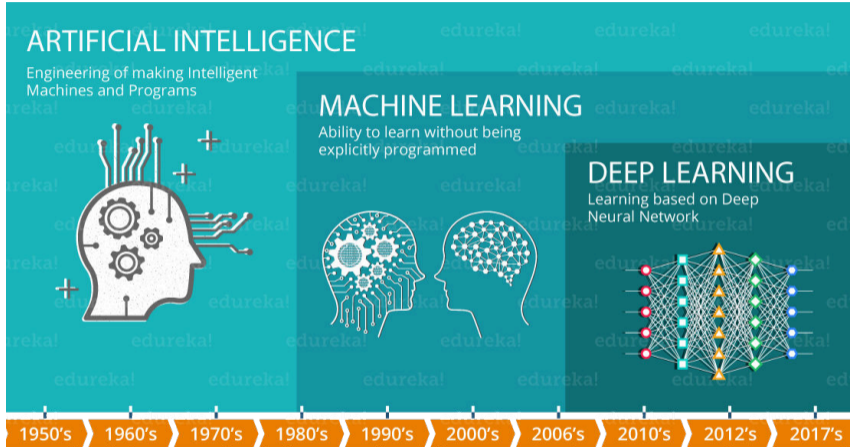


Image: [www.quora.com](http://www.quora.com)

...a well-known, widely accepted view but also a limited view that ignores others key ingredients such as evolutionary algorithms...



# AI for 3D Point Clouds

## Real-Time Immersive Visualization of Indoor Environments



Image: HPI, Data: DLR

## As-Is Building Models



Image: HPI

# AI for 3D Point Clouds

## Virtual 3D City Models



Image: HPI, Data: Stadt Landshut

## Hardware and Software for Generating 3D Point Clouds

- Remote Sensing
- Photogrammetry
- Model Discretization
- Procedural Generation
- ...



- Represent geometry by *discrete, unstructured sets of points* (e.g., in an Euclidian space)
- Approximate *any shape, any topology, and any geometry*
- *No assumptions* regarding density, regularity, or statistic properties
- Simple and powerful approach to *geometric modeling*
- *Big spatial data*

<b>Dataset</b>	<b>Area</b>	<b>Density</b>	<b># Points</b>
Berlin	890 km <sup>2</sup>	100 pts/m <sup>2</sup>	80 billion
Baden-Württemberg	36,000 km <sup>2</sup>	25 pts/m <sup>2</sup>	900 billion
Frankfurt	250 km <sup>2</sup>	15-20 pts/m <sup>2</sup>	7.1 billion
Netherlands (AHN2)	42,000 km <sup>2</sup>	6-10 pts/m <sup>2</sup>	>600 billion

- Spatio-temporal point clouds
- Frequent acquisition (e.g., day-to-day, on-demand, real-time, ...)
- High density, high redundancy
- High degree of redundancy
- Irregularly distributed
- Overlapping extensions, but no exact matches

## **AI-Based "Interpretation"**

- Computing Segmentations and Classifications
- Distilling Semantics
- Building Spatial Models
- Deriving Descriptions
- Representing Phenomena
- ...



## ML-Based Vegetation Detection



Image: HPI & PCT

## Change Detection based on 4D Point Clouds

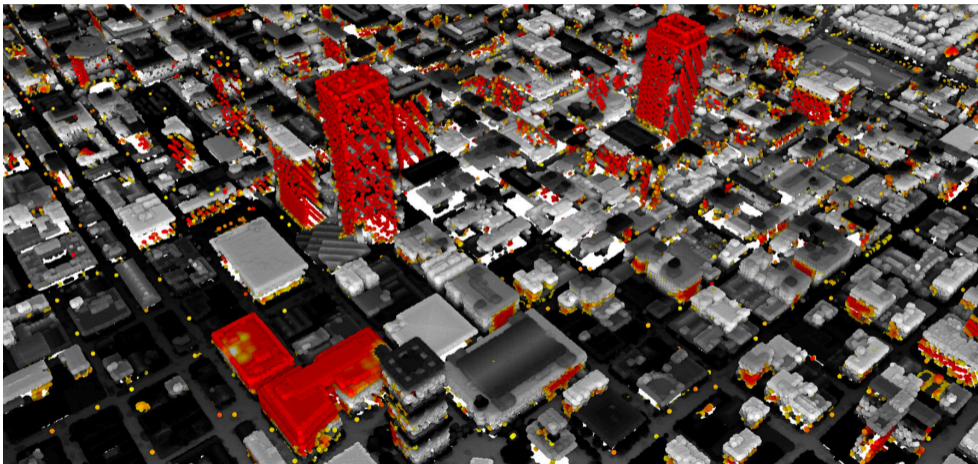


Image: HPI

## ML-based Analysis of Mobile Mapping Scans

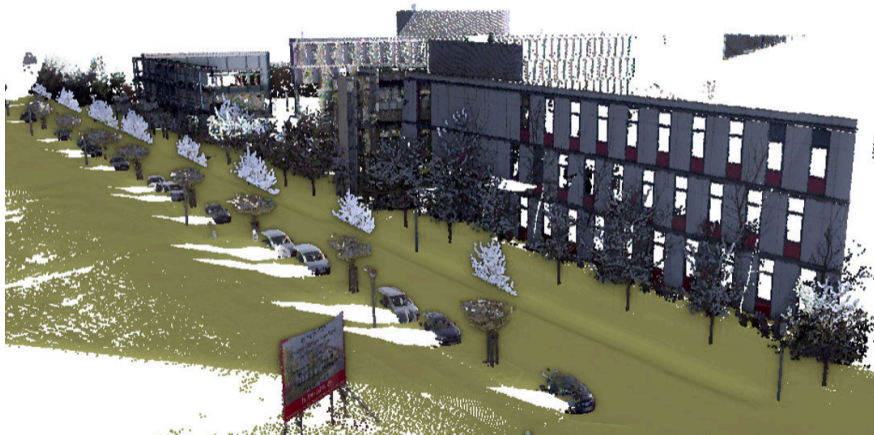


Image: HPI & PCT

## ML-based Analysis of Mobile Mapping Scans

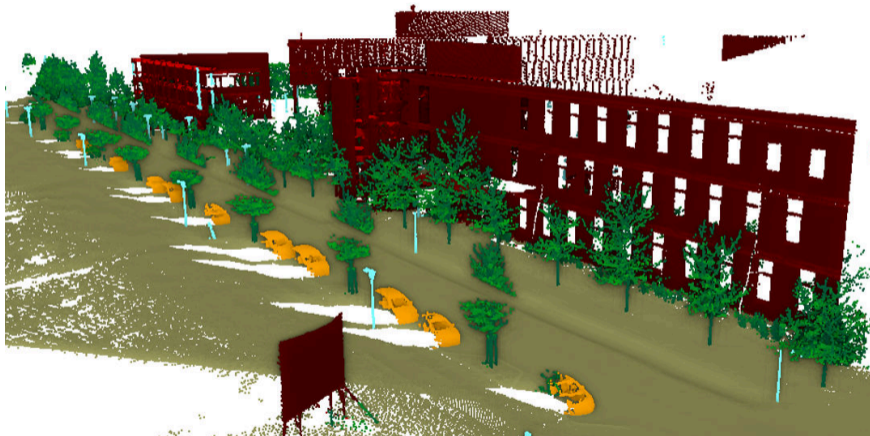


Image: HPI & PCT

## ML-Based Analysis of Railroad Scans

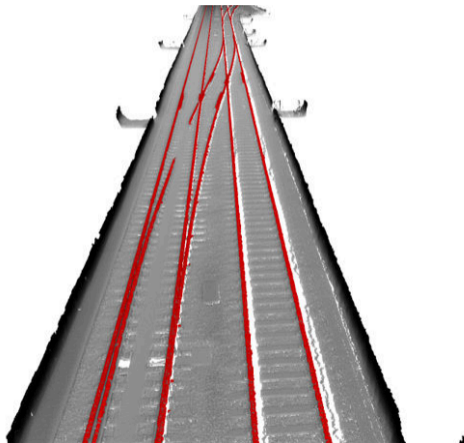


Image: HPI & PCT

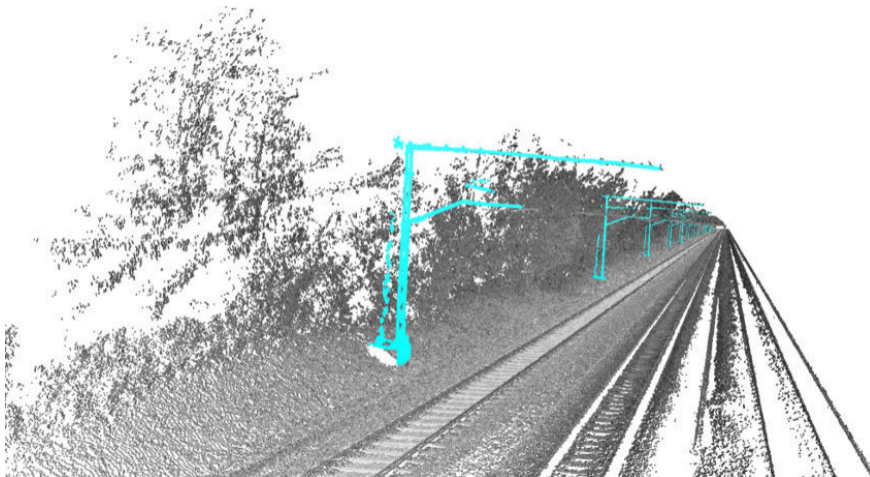


Image: HPI & PCT

## ML-Based Asset Detection using Ground Penetration Radar

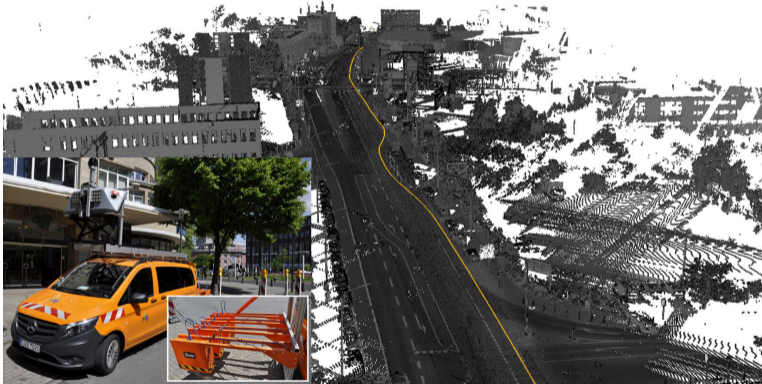


Image: HPI & PCT

## ML-Based Asset Detection using Ground Penetration Radar

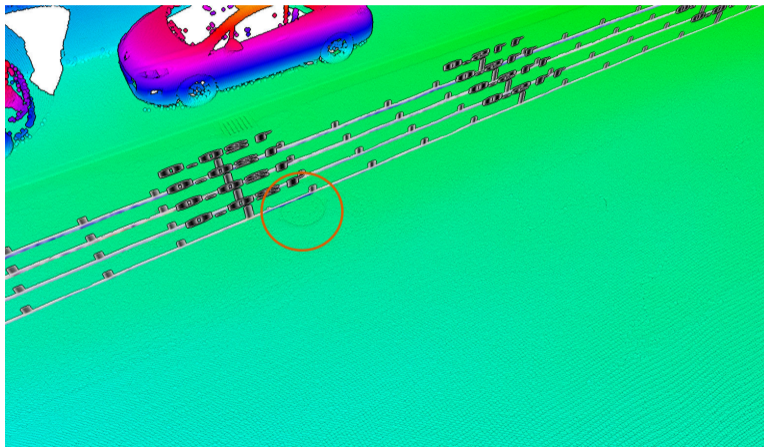
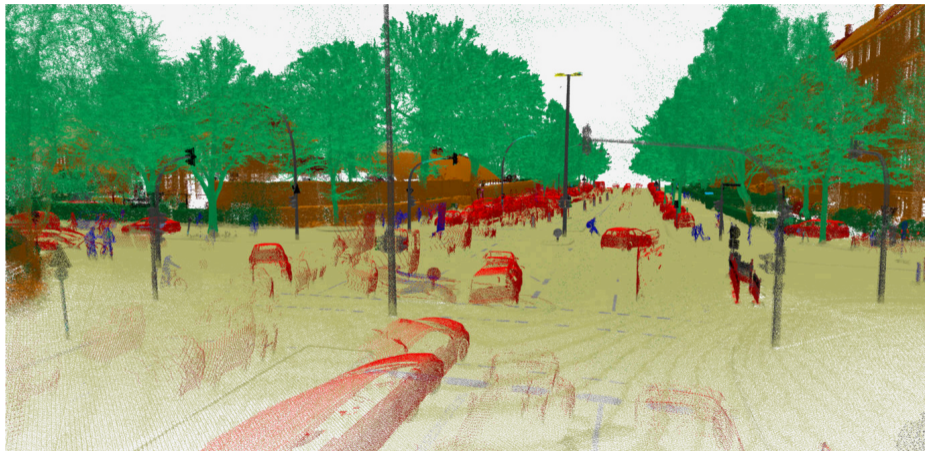


Image: HPI & PCT



## Point Cloud Cleansing



Removing artifacts from mobile scanning (Image: HPI)

## Complex Classifications

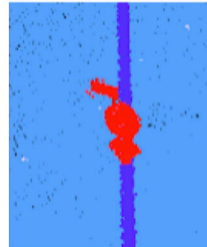
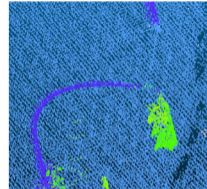
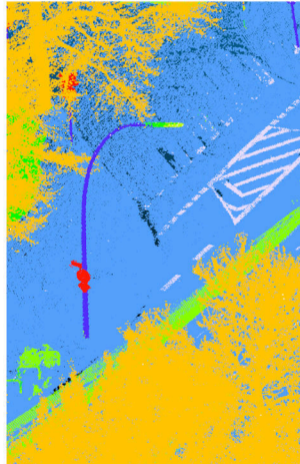
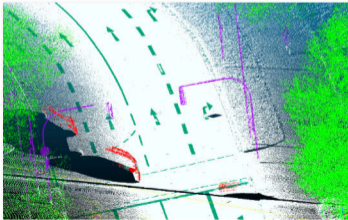
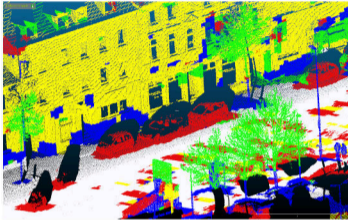


Image: HPI

# Examples for 3D Point Cloud Interpretation

## Compound Classifications

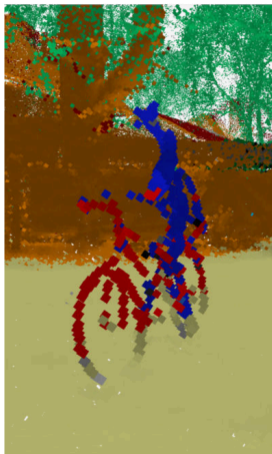


Image: HPI

# AI for Location Intelligence

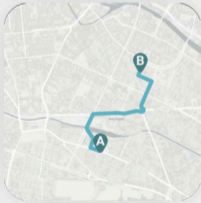
## APSP as Generic Spatial Access Function

- Road Networks
- Public Transportation Networks
- Infrastructure Networks

### A to B (SPSP)

#### Single-Point Shortest-Path

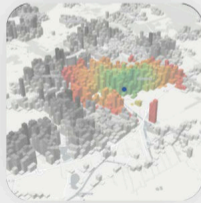
- "What is the shortest path from a specific location to another specific location?"



### A to X (SSSP)

#### Single-Source Shortest-Path

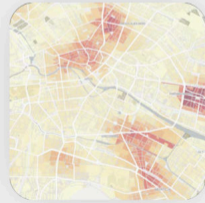
- "How many people can reach a particular location in a particular time?"



### X to X (APSP)

#### All-Pairs Shortest-Paths

- "Where's the location most people can reach?"



[www.targomo.com](http://www.targomo.com)

For a moment, let us think of

- each address (e.g., street + street number)
- each customer address
- each road segment
- each bus station
- each infrastructure element
- each household
- ...

as a **geo-referenced, high-dimensional feature vector** in a high-dimensional feature space (i.e., high-dimensional point cloud space).

## AI-Based Prediction for Location Analytics



## AI-Based Prediction for Location Analytics



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# Conclusions

## **Naturalness Hypothesis**

*Most human utterances are far simpler and much more repetitive and predictable.*

## Computer programs seen as text corpora<sup>1</sup>

“Programming languages, in theory, are complex, flexible and powerful, but the programs that *real people actually write* are mostly simple and rather repetitive...”

“The measure *perplexity* used in its log-transformed version is called *cross-entropy*—roughly speaking, it tells how surprised a model is for a document.”

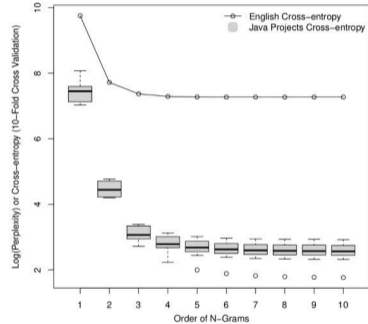


Figure 1. Comparison of English cross-entropy versus the code cross-entropy of 10 Java projects.

<sup>1</sup>A. Hindle, “On the Naturalness of Software”, ACM, 2016

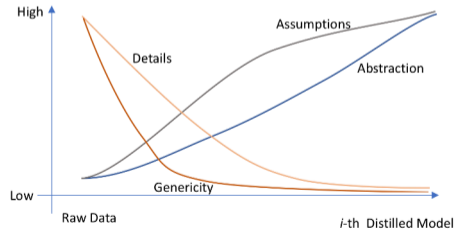
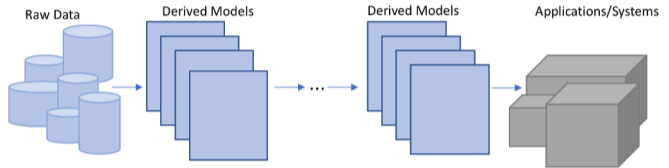
## **Naturalness Hypothesis for Point Clouds**

“ The *3D point cloud* is a form of *natural communication*; *point cloud corpora* have similar statistical properties to natural language corpora; and these properties can be exploited to build new geospatial tools. In fact, these “utterances” can be very usefully modeled using modern statistical methods. ”

“Most *3D point clouds* are just repetitive and predictable.”

# Conclusions

- AI simplifies data processing pipelines
- Vanishing need for explicit models



- AI reduces software complexity

```
if (submissionFlag.equals("AL")) {
    if (orgName.contains(" WC ") || orgName.contains(" GL ") || orgName.contains(" UMB ") || orgName.contains("Umbrella") || orgName.contains(" WC ") || orgName.contains(" wc ") || orgName.contains(" _wc")
        || orgName.contains(" _GL ") || orgName.contains(" gl ") || orgName.contains(" _gl ")
        || orgName.contains(" _UMB ") || orgName.contains(" umb ") || orgName.contains(" _umb ")
        || orgName.contains("Liability") || orgName.contains("Directors & Officers") || orgName.contains("Umbrella")
        || orgName.contains("umbrella") || orgName.contains("D&O") || orgName.contains(" DO ") || orgName.contains(" _DO")
        || orgName.contains(" Umb ") || orgName.contains(" _Umb ") || orgName.startsWith("GL ") || orgName.startsWith("gl ")
        || orgName.startsWith("WC ") || orgName.startsWith("wc ")){
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        || orgName.contains("Liability") || orgName.contains("Directors & Officers") || orgName.contains("Umbrella")
        || orgName.contains("umbrella") || orgName.contains("D&O") || orgName.contains(" DO ") || orgName.contains(" _DO")
        || orgName.contains(" Umb ") || orgName.contains(" _Umb ") || orgName.startsWith("AL ") || orgName.startsWith("al ")
        || orgName.startsWith("WC ") || orgName.startsWith("wc ")){
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}

if (submissionFlag.equals("WC")){
    if (orgName.contains(" AL ") || orgName.contains(" GL ") || orgName.contains(" UMB ") || orgName.contains("Umbrella") || orgName.contains(" AL ") || orgName.contains(" al ") || orgName.contains(" _al ")
        || orgName.contains(" _GL ") || orgName.contains(" gl ") || orgName.contains(" _gl ")
        || orgName.contains(" _UMB ") || orgName.contains(" umb ") || orgName.contains(" _umb ")
        || orgName.contains("Liability") || orgName.contains("Directors & Officers") || orgName.contains("Umbrella")
        || orgName.contains("umbrella") || orgName.contains("D&O") || orgName.contains(" DO ") || orgName.contains(" _DO")
        || orgName.contains(" Umb ") || orgName.contains(" _Umb ") || orgName.startsWith("GL ") || orgName.startsWith("gl ")
        || orgName.startsWith("AL ") || orgName.startsWith("al ")){
        else{uploadAttachment=true;}
    }
}

if (submissionFlag.equals("Others")){
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        ){}
    else{uploadAttachment=true;}
}
```

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