Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

Data: Lab Munich

GeometricalDeepLearning on 3D Models: Classification for Additive Manufacturing

01.04.2021

Agenda

Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

1. Introduction Data:Lab
2. Status quo
3. Project Vision
4. Project plan, Milestones

Get to know the team
About us

Andrii Kleshchonok

Gülce Cesur

Marc Hilbert

Marcus Danielz

At Data:Lab Munich we solve real problems with the use of data and AI.

/ Sustainable data driven products.

/ Provide better customers experience.

/ Improve organisations’ internal processes.

/ Volkswagen Group DNA.

Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

Paving the way for digital transformation.

With a team of forward looking experts turning the most valuable asset of our entire organisation - data - into business solutions.

20+
nationalities

72+
team members

160
projects

+22
languages

Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

EPT Team

3 key business domains

A small and agile structured group of people who research and develop projects primarily for the sake of radical innovations in engineering and production.

Engineering

- Integrate with development teams
- Showcase ML in motorsports
- Get into vehicles

Connected Car

- Act as a central hub for ML
- Integral part for all data
- Data brokerage topics in VW

Production

- Support novel manufacturing technologies with ML
- Digital Production Platform

Production

Additive Manufacturing

Additive manufacturing technologies, also known as 3D printing, and their advances have transformed the potential ways in which components are designed, developed, manufactured, and distributed.

/ 3D printing shows its strengths, where conventional manufacturing processes reach their limits. These include...

...high geometric freedom of design
...functional integration
...strong and lightweight parts
...low resource consumption
...production on demand

/ In the automotive industry 3D printing is mainly used to manufacture...

...prototypes
...operating equipment
...customized parts
...components for exhibition models and pre-series vehicles
...motorsport parts

1: https://unsplash.com/photos/1M7_12ynKG8

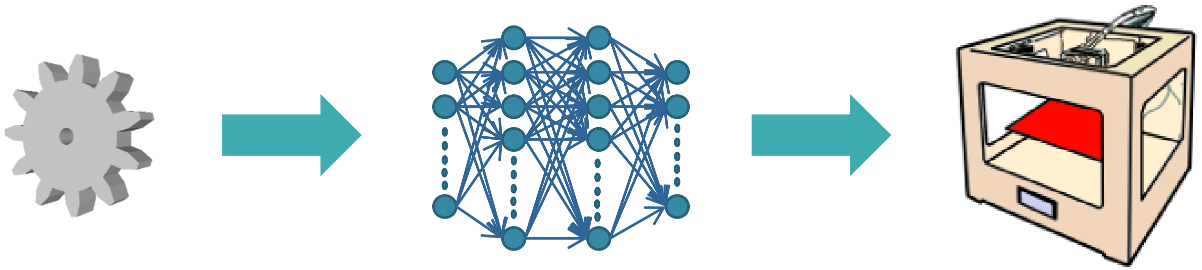
Use-case

Check if specific parts can be produced with a 3D printer

- *Status quo:* In order to check whether a part can be produced with a 3D printer, the geometric elements of the parts are usually measured manually in CAD software and it is checked whether they are not below the minimum dimensions specified by the 3D printer manufacturer.

- *Problem:* The manual check is very time-consuming due to the many geometric elements a part can consist of

- *Our approach:* Train a Machine Learning model that checks if all requirements are fulfilled to produce a part on a 3D printer



1: https://ten-thousand-models.appspot.com/
2: https://www.flickr.com/photos/zmaker/13618450884/

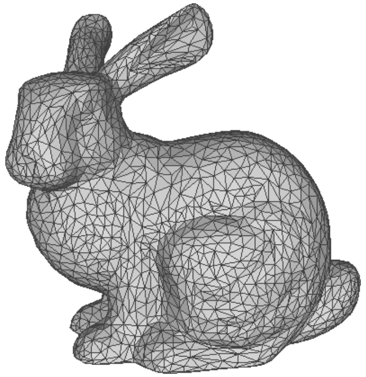
Use-case

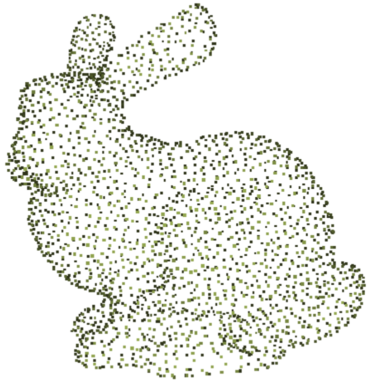
Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

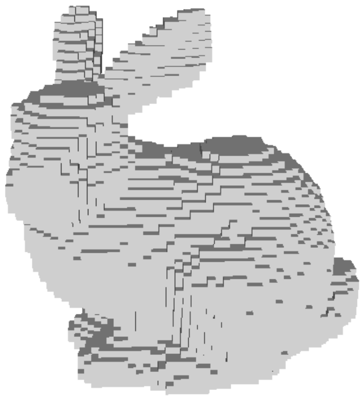
Recommended feature sizes: Are features properly sized?

FEATURE	RPU 70	RPU 130	MPU 100	EPU 40 EPU41	FPU 50	CE 221	EPX 82	PR 25	UMA 90	SIL 30
Wall Thickness - Unsupported (mm)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Wall Thickness - Supported (mm)	1.0	1.5	1.0	1.0	1.0	1.0	1.5	1.0	1.0	1.5
Positive feature size XY (mm)	0.4	0.3	0.4	0.5	0.5	0.4	0.3	0.6	0.4	1.0
Minimum hole size XY (mm)	0.5	0.5	0.9	0.5	0.5	1.0	0.6	0.9	0.9	2.0
Positive feature size Z (mm)	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.0
Minimum hole size Z (mm)	0.6	0.5	0.8	0.5	0.5	0.7	0.9	0.6	0.8	2.0
Unsupported angle from horizontal (deg)	30	40	40	40	35	40	40	30	30	40

Representations of 3D data







	Mesh grid	Point cloud	Voxel
Textures	++	-	+
Memory	++	+	-
Neural network Functionality available	+	+	++

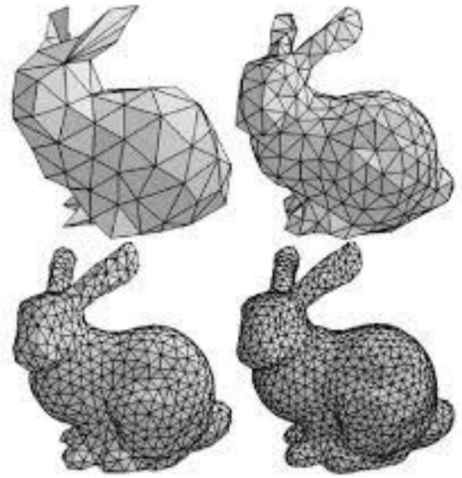
1: http://graphics.stanford.edu/data/3Dscanrep/

Why is the analysis of 3D shapes complicated?

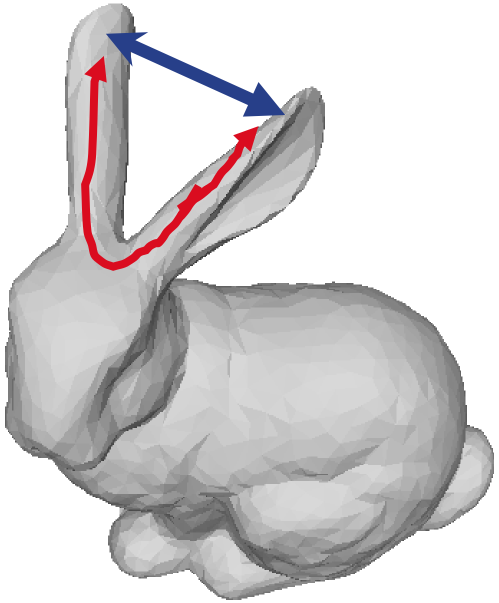
Input data is different!

Input types

Data complexity and number of inputs



Non-Euclidean



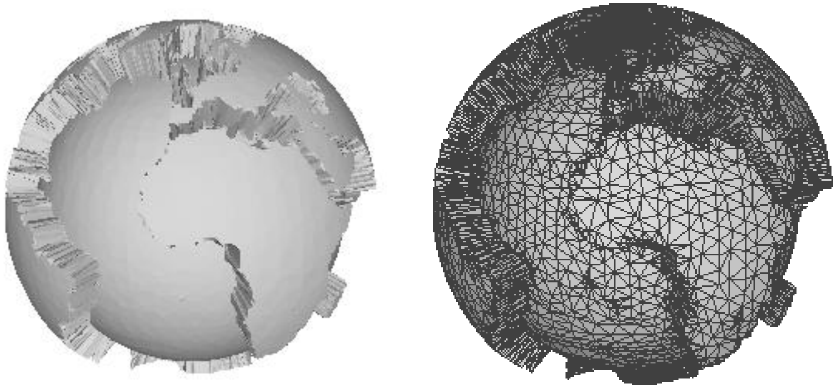
- Data type-based transformation
- Special operations/layers
- Different information contained
- Complexity in data handling

1: http://graphics.stanford.edu/data/3Dscanrep/

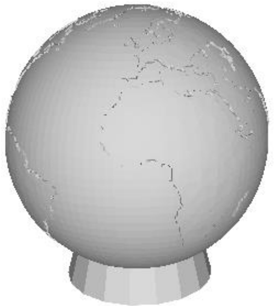
Problem definition

Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

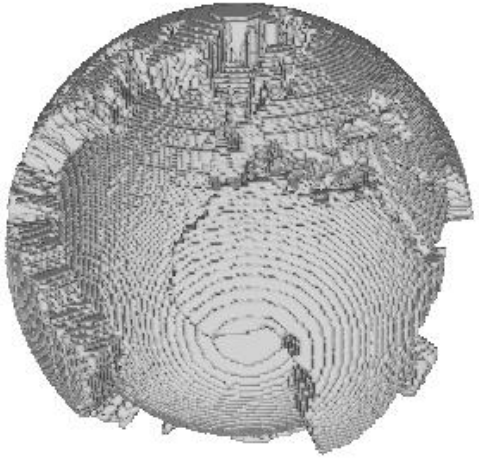
Grid representation



Land

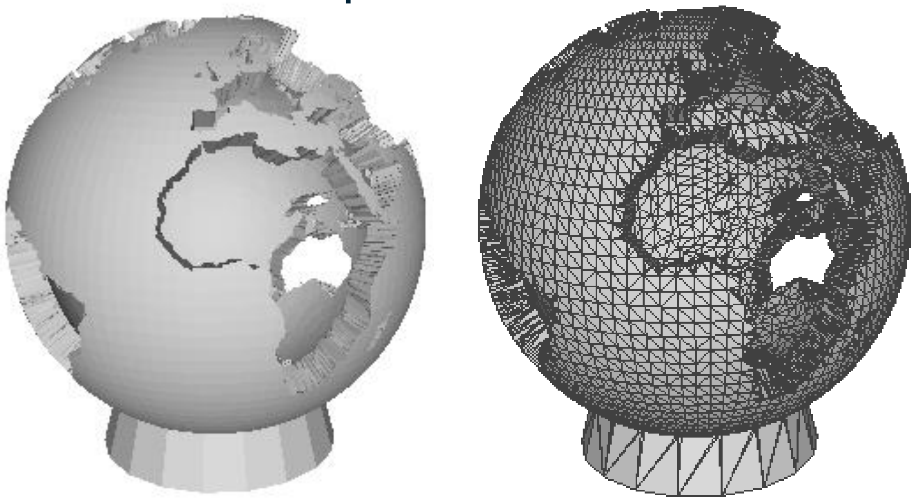


Globe

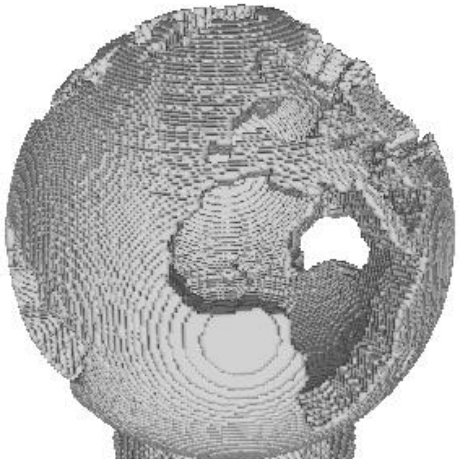


Land Voxel representation

Grid representation



Water

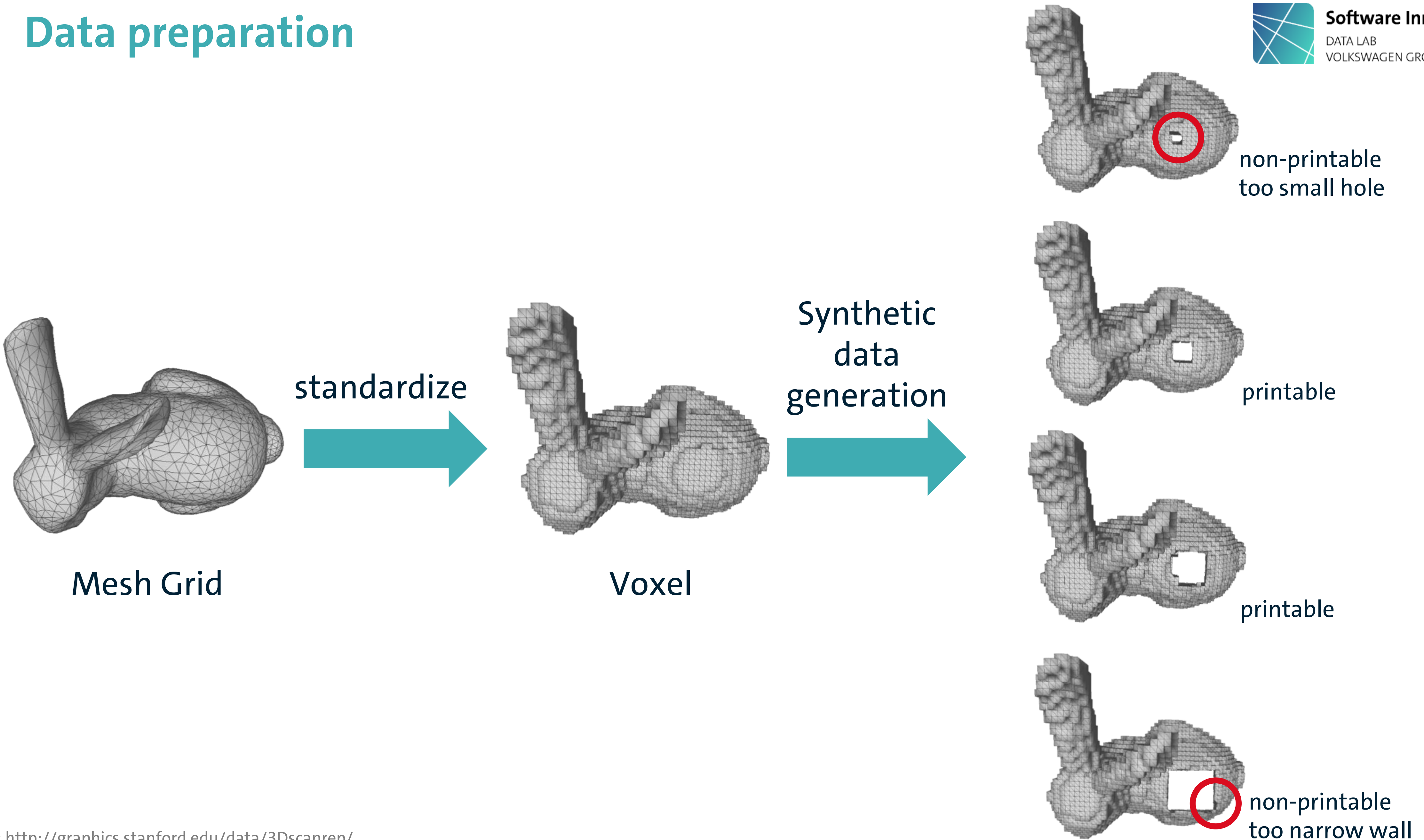


Water Voxel representation

1: https://ten-thousand-models.appspot.com/

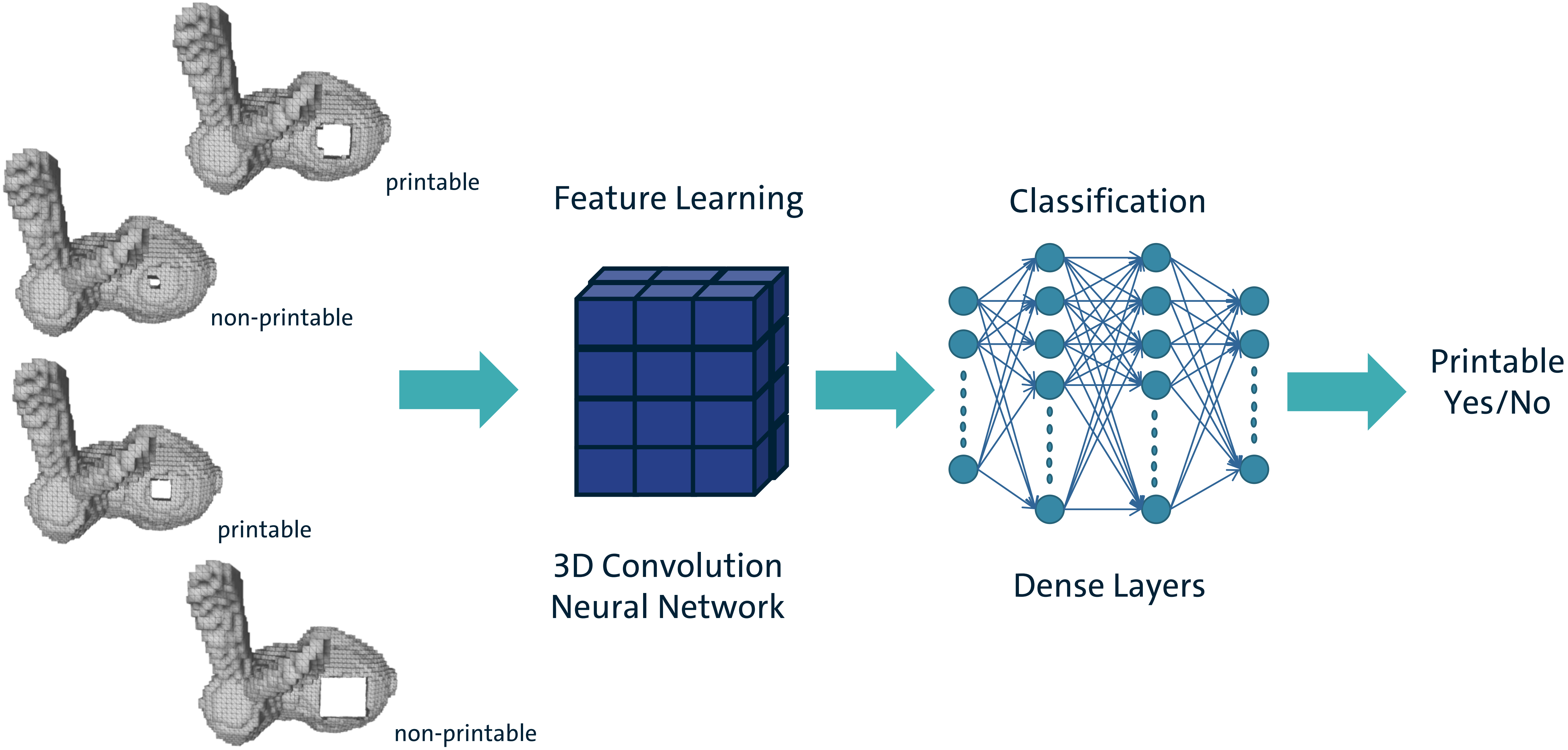
Data preparation

Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP



1: http://graphics.stanford.edu/data/3Dscanrep/

Neural network classifier



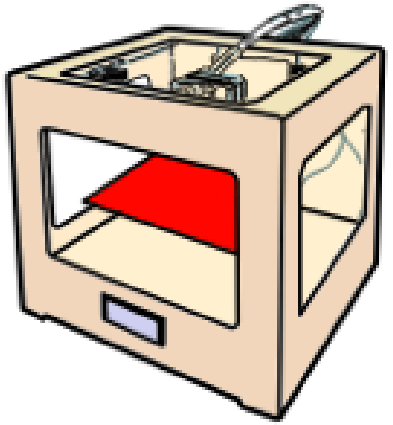
Project vision

Develop data pipeline and machine learning algorithm for classification between printable and non-printable 3D models

Object Database

ML pipeline

Automatically select printable objects



Print

1: https://ten-thousand-models.appspot.com/
2 https://www.flickr.com/photos/zmaker/13618450884/
3 https://www.flickr.com/photos/dizingof/14406296731/

Geometrical deep learning on 3D models: classification for additive manufacturing

Content / Work packages

- Preprocessing: clean data, normalize data of printable 3D shapes, convert to the voxel representation
- Synthetic data: generate data by inserting defects into 3D shapes that lead to the non-printable forms
- Modelling: develop neural network- based solution for classification between printable and non-printable shapes
- Testing: test solution on real-world 3D shapes examples

Project deliverables

- Data pipeline
- Proof of Concept, Code implementation
- Report/ Documentation

Technical specifications

Data sources:

- Open Source dataset of 3D printable shapes fused synthetic datasets

Algorithms/methods:

- Neural Networks for 3D data classification based on voxel data
- 3D convolution neural nets and transfer learning
- Classical Differentiable geometry methods

Software/IT:

- Python, sklearn, PyTorch, Keras, Tensorflow, 3D graphics Frameworks (Blender, Unity …)

Project plan

Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

Develop data pipeline and machine learning algorithm for classification between printable and non-printable 3D models

#	Work package	Deadline
1	Preprocessing	2 CW
2	Synthetic data generation	2 CW
3	Modelling	5 CW
4	Testing	2 CW
5	Inference Pipeline	3 CW

Communication & Collaboration
Working together

• Kick-off:	today, 1 April 2021
• Project start:	13 April 2021
• Weeklies:	tbd.
• Final meeting:	tbd.

• Communication tool for calls:	E-mail, Teams
• Collaboration tool:	Trello, GitHub

We are happy to welcome you on board!

Software Innovation Center
DATA LAB
VOLKSWAGEN GROUP

For technical questions please feel free to contact us:

Name: Andrii Kleshchonok
E-Mail: Andrii.kleshchonok@volkswagen.de
Mobile: +49 152 22923066

Name: Marcus Danielz
E-Mail: marcus.danielz1@volkswagen.de
Mobile: +49 152 22859364