Building an Open Knowledge Network (OKN) Graph *in* Product Design & Manufacturing "MOKN"

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1

70% of US Manufacturing is performed by US Small Businesses

Norbert

Many of these small manufacturers have razor thin margins of around 5% to 7%.

Projecting Capabilities to designers inexpensively and enable aid in business development activities.

2

STEM Product Designers in Startups & Medium Scale Companies

Sara

📞 Finding the Right Manufacturer is important for mechanical product designers who want quick turn around for prototypes.

💬 Quotations from the Manufacturer can take anywhere from 1-2 weeks to be delivered and finalized.

3

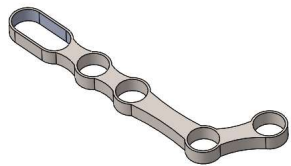## Can a 7-yr child engage in Product Design ?

4

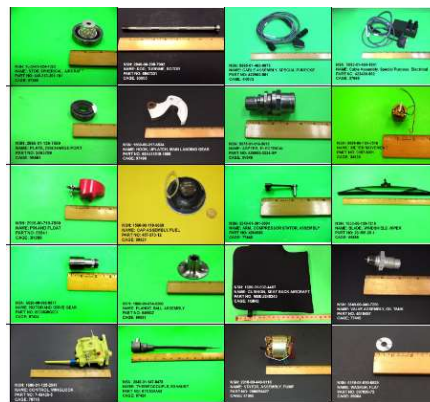# Vision for Democratizing Manufacturing
Lower barriers to Design and Making of Product

Algorithms Assist Child To Design Fully Functional Toy

Algorithms Finalize a Personalized Toy Fire Truck. Parent orders Toy!

Order instantly routed to available factories/machines capable of fulfilling order.

Child sketches his version of a firetruck toy on an iPad.

One-off Personalized toy delivered back to client.

Other Examples

Personalized Medical Implant

Parts Catalog at DoD DLA

Vintage Automobile Components

Often on-Demand, Need Very Limited Quantities, Specific Source Requirements and Restrictions
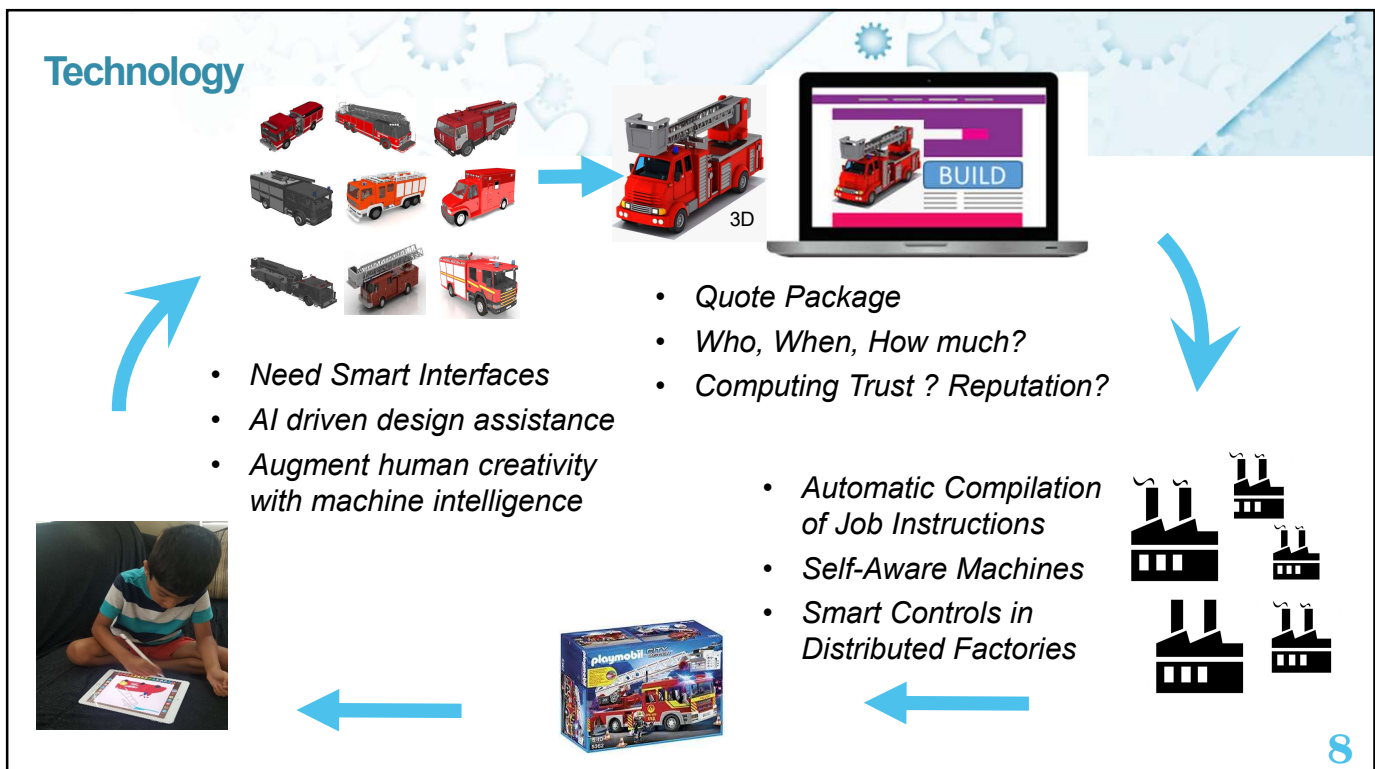
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Why is this **Not Possible** Today ?
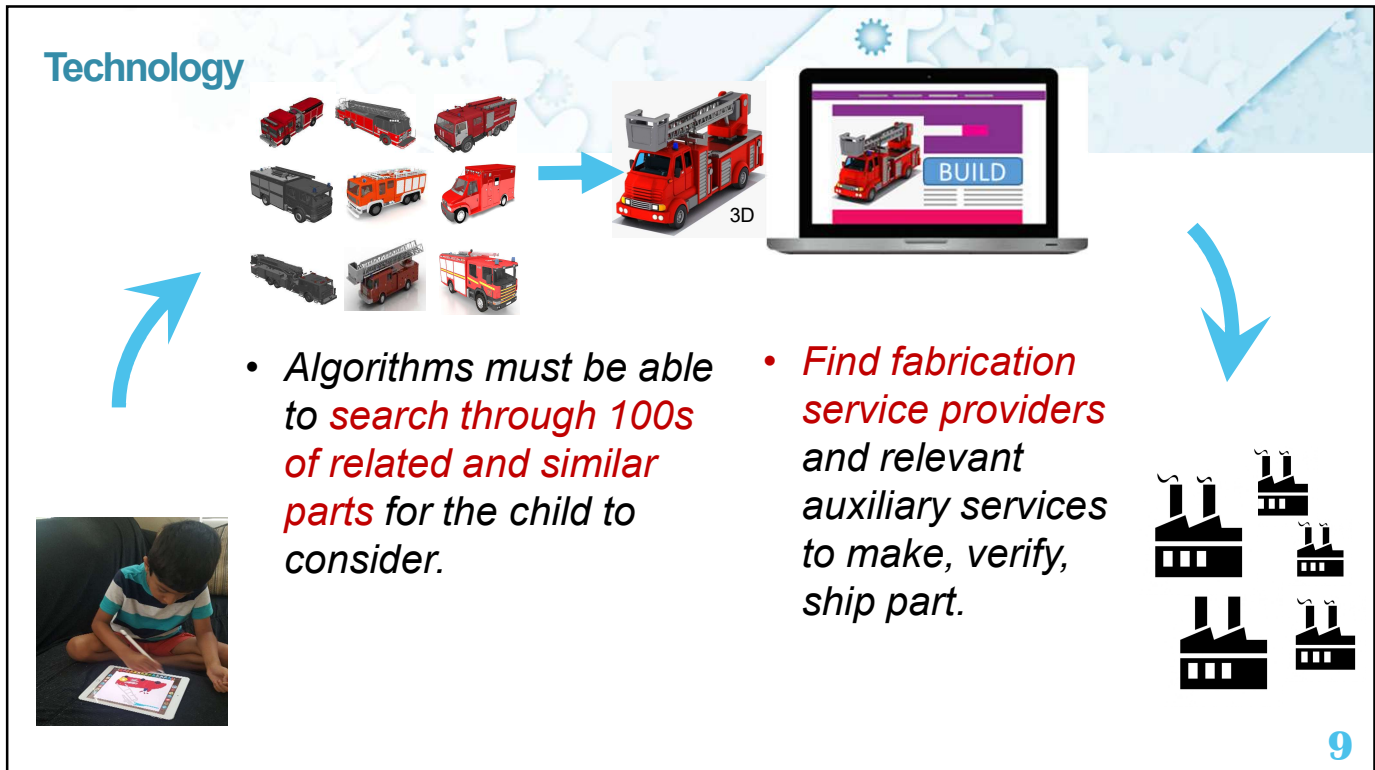
Personalization of Products is Expensive

Who Can Make What, and When and How much ?

Trust and Reputation of Service Providers

Privacy Concerns & Unavailable Data Provenance

7

Technology

- *Need Smart Interfaces*
- *AI driven design assistance*
- *Augment human creativity with machine intelligence*

3D

BUILD

- *Quote Package*
- *Who, When, How much?*
- *Computing Trust ? Reputation?*

- *Automatic Compilation of Job Instructions*
- *Self-Aware Machines*
- *Smart Controls in Distributed Factories*

8

Technology

- *Algorithms must be able to search through 100s of related and similar parts for the child to consider.*

- *Find fabrication service providers and relevant auxiliary services to make, verify, ship part.*

BUILD

3D

9

SEARCH
Making 3D Product Model Data
'FAIR'

NC STATE UNIVERSITY

3D Product Model Search
Using Images and 3D Model Templates to find other similar or related 3D parts/models/assemblies

Searching for 3D Product Models in Online Galleries

Reusable 3D Product Models in Design

GrabCAD.com & Thingiverse
100M+ individual parts;

Autodesk Fusion Gallery
10M+ part models

Example of 3D Product Data: LINK

NC STATE UNIVERSITY

Generating 3D Model Corpus : FabWave Repository

Reusable 3D Product Models in Design

> 110K+ 3D CAD Parts	> 1TB File Content	Raw, . STEP, .STL formats	> 40 Part Categories

NC STATE UNIVERSITY

Generating Model Corpus – NYU ABC Dataset

https://deep-geometry.github.io/abc-dataset/

| > 2M+ 3D CAD Parts | > 10TB File Content | .STEP formats | NO Part Categories |

SOURCE: OnShape (PTC) Public 3D Model Content : Dr. Daniele Panozzo (NYU)

13

Data Preparation

Created 3D Model Template Categories – Manually classified 1200+ models to 10 categories

Large Prismatic

Large Cylindrical

Gear-Like Parts

Screws

Simple Gaskets

Full-Face Gaskets

Nuts

Pipes

Springs

Brackets
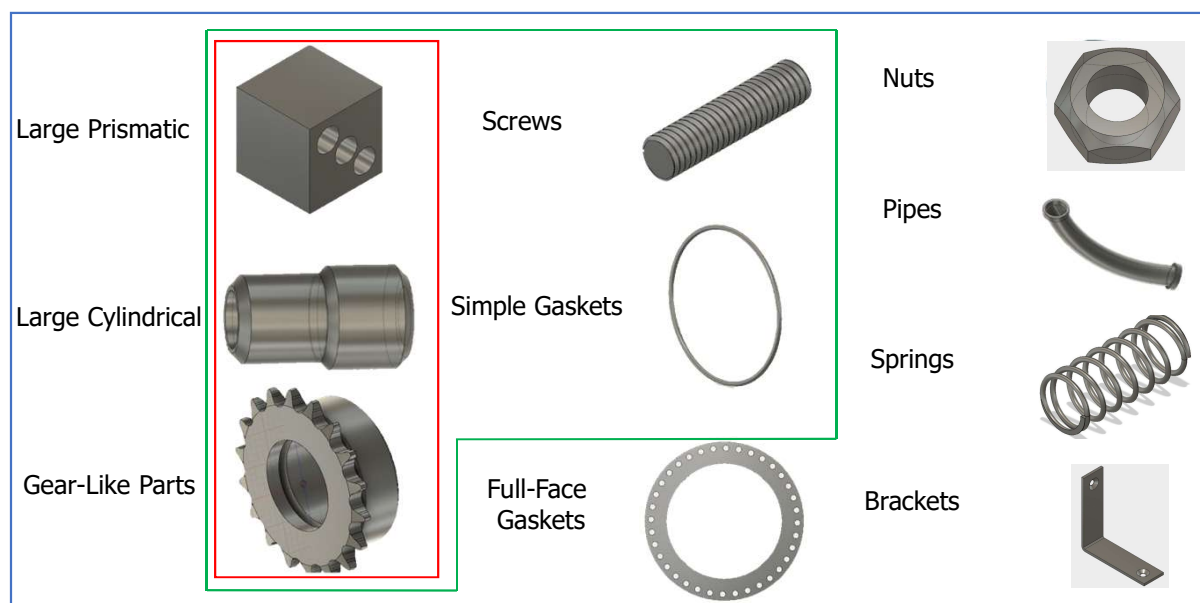
14

Searching for 3D Product Models – CAD2Vec

Using Geometric Deep Learning signatures to 'find' 3D Product Models

Use for search : Numerical Vector

Angrish et. al., 2019
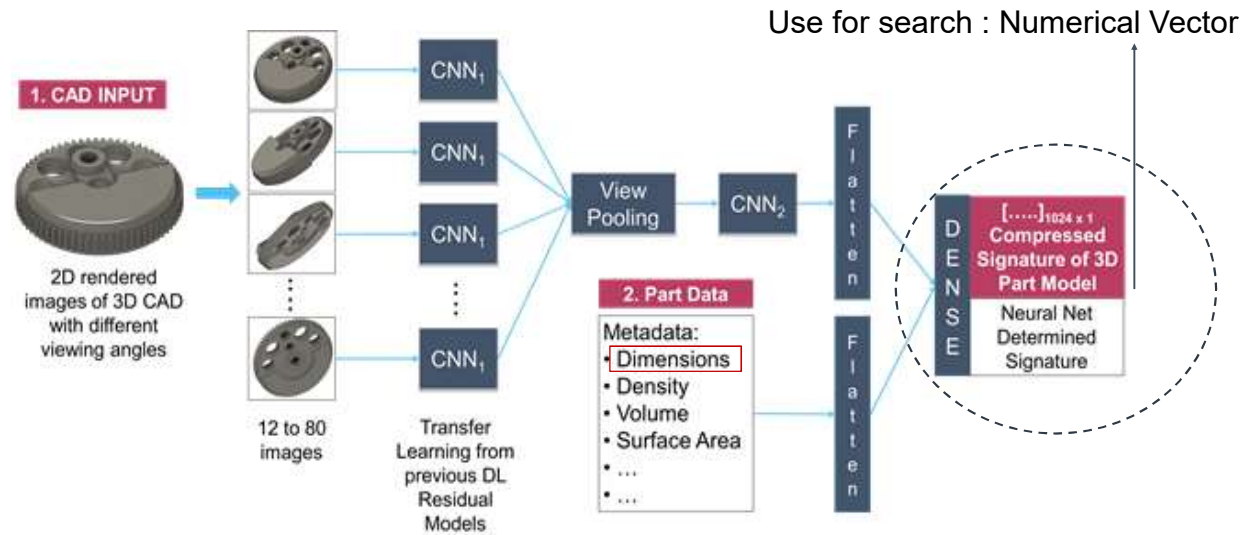
Results: OLD Shape Descriptor – Spherical Shape Harmonics (SPH)

Voxel Based and heavily dependent on resolution and 'HAND' Drawn
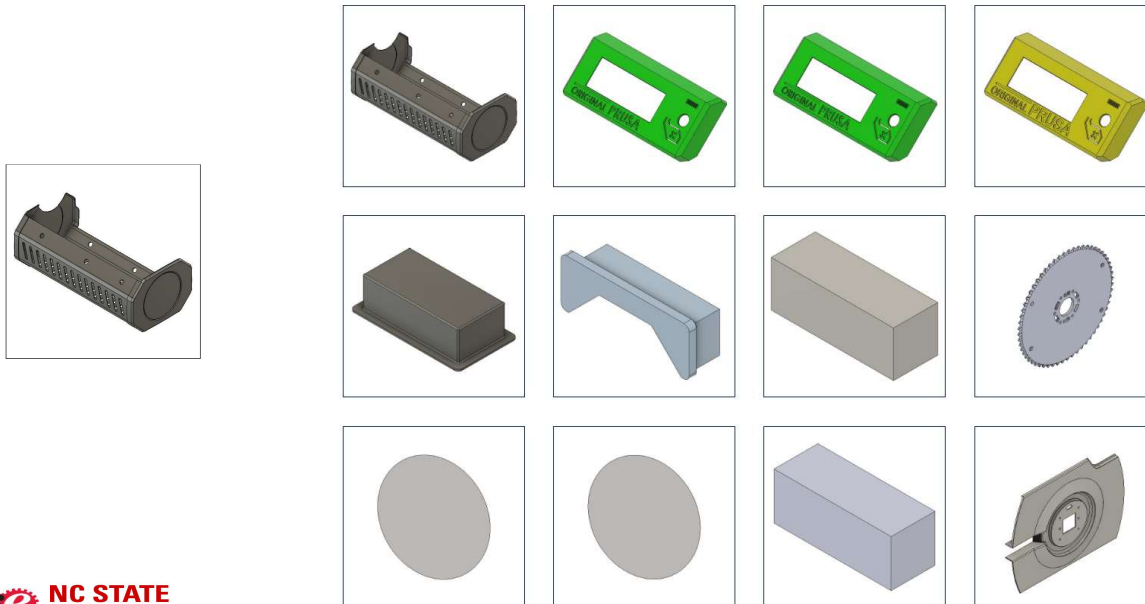
Results: Computer Generated Numerical Signature

Multi-View CNN based Descriptor to Search Across >100K+ 3D models
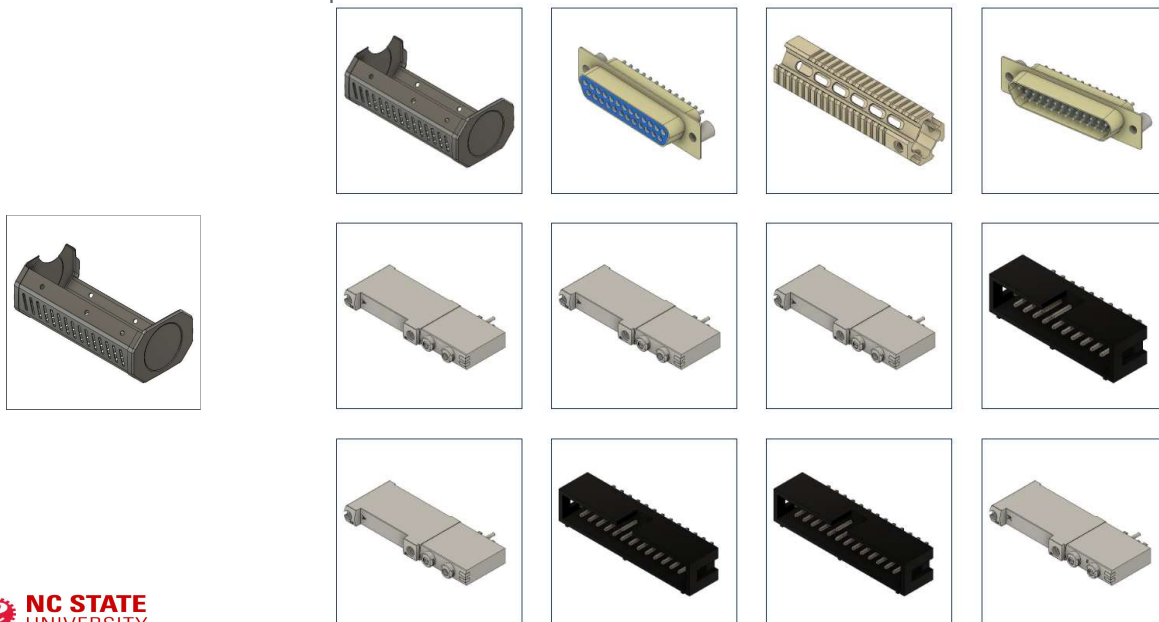
Graph of Related 3D Models
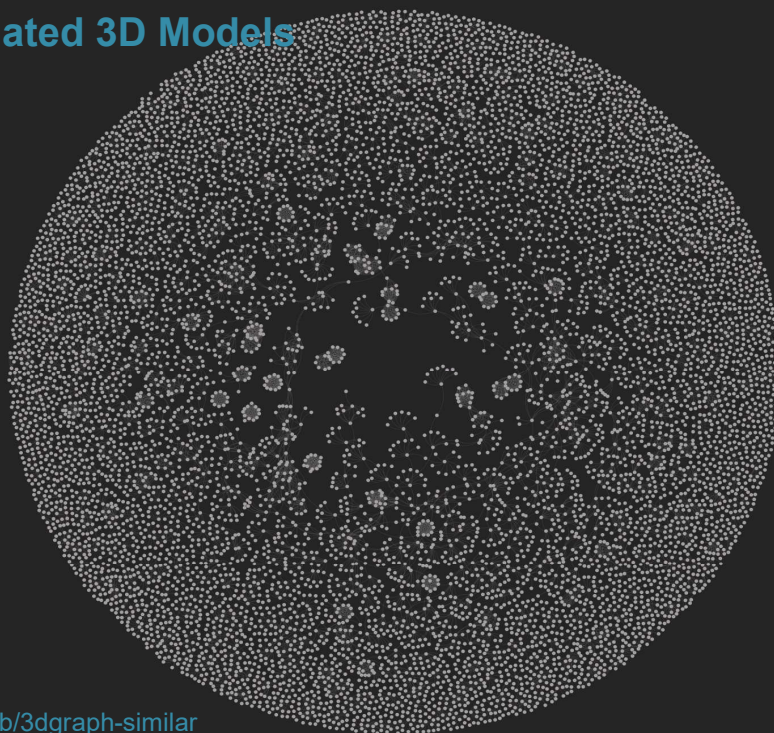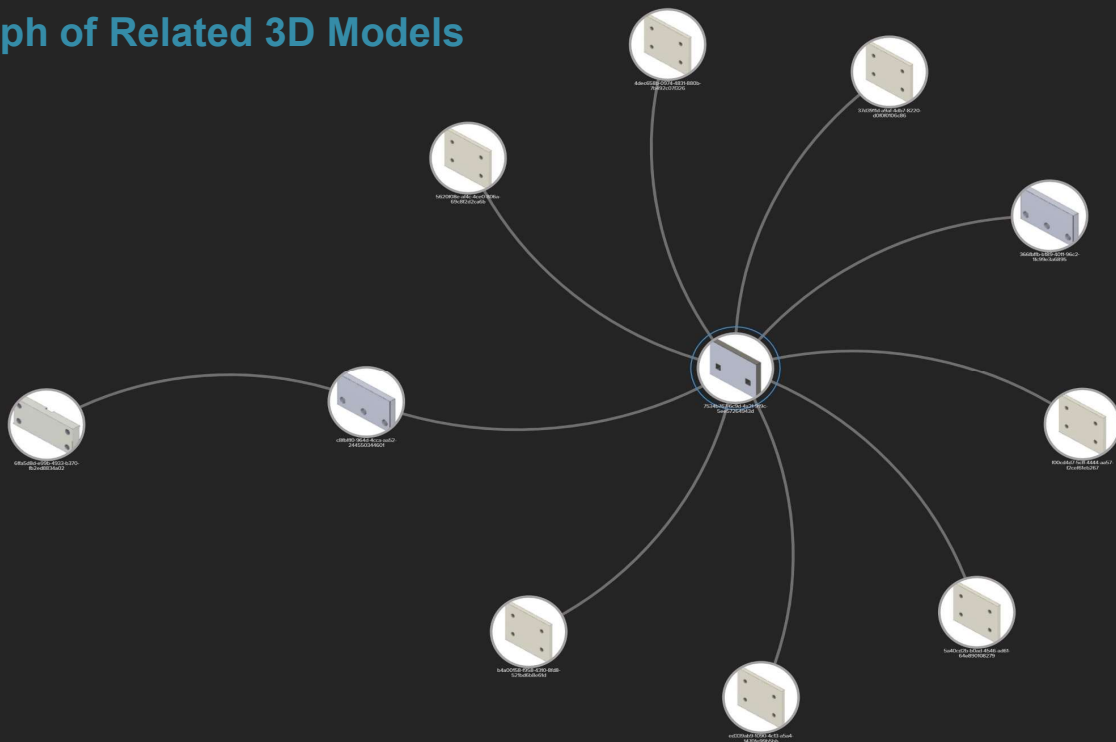
https://kumu.io/starlyb/3dgraph-similar

Graph of Related 3D Models

Graph of Related 3D Models

Graph of Related 3D Models
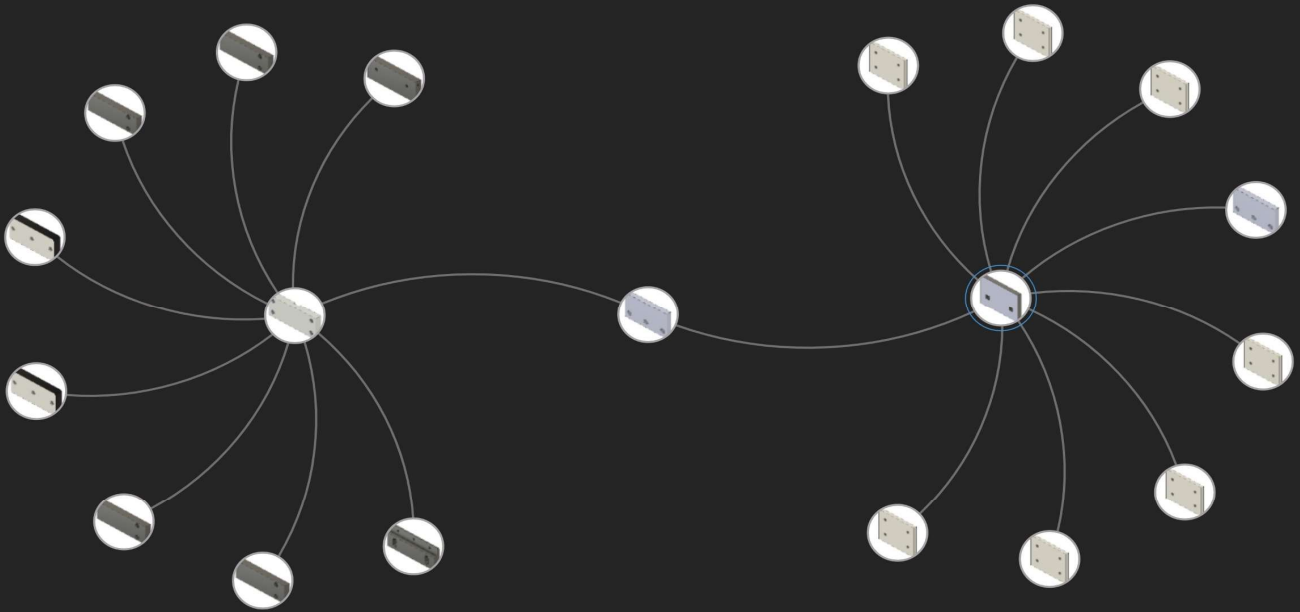
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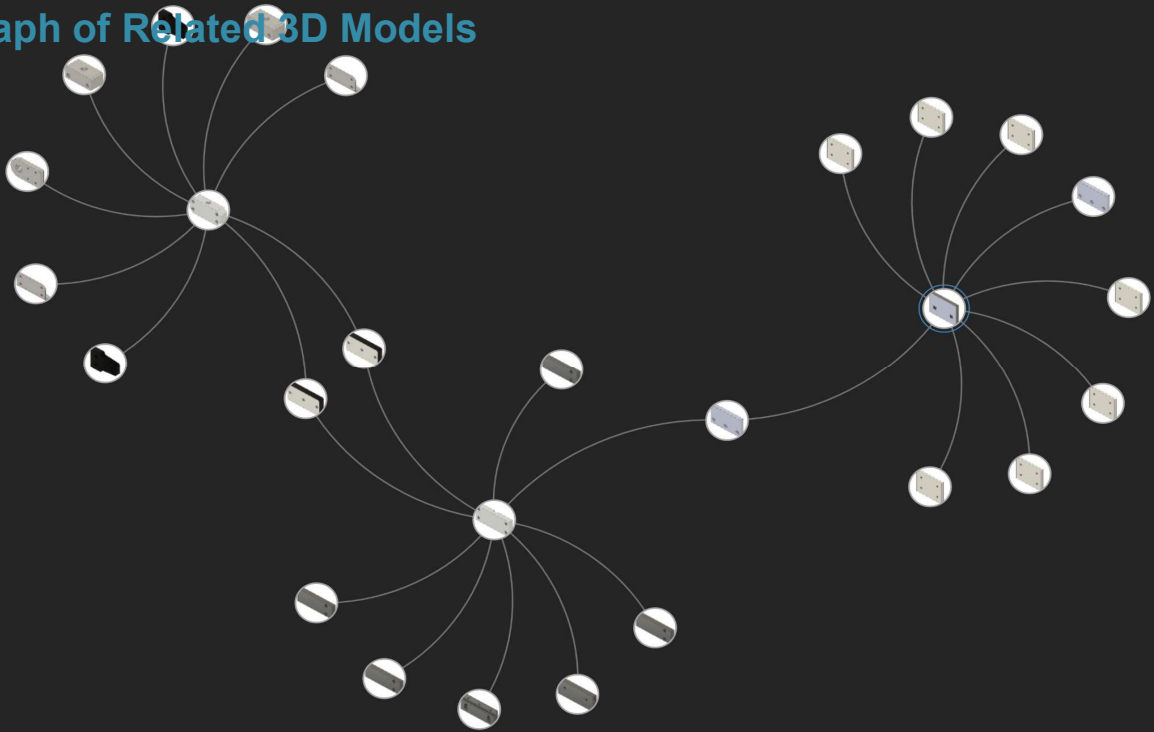
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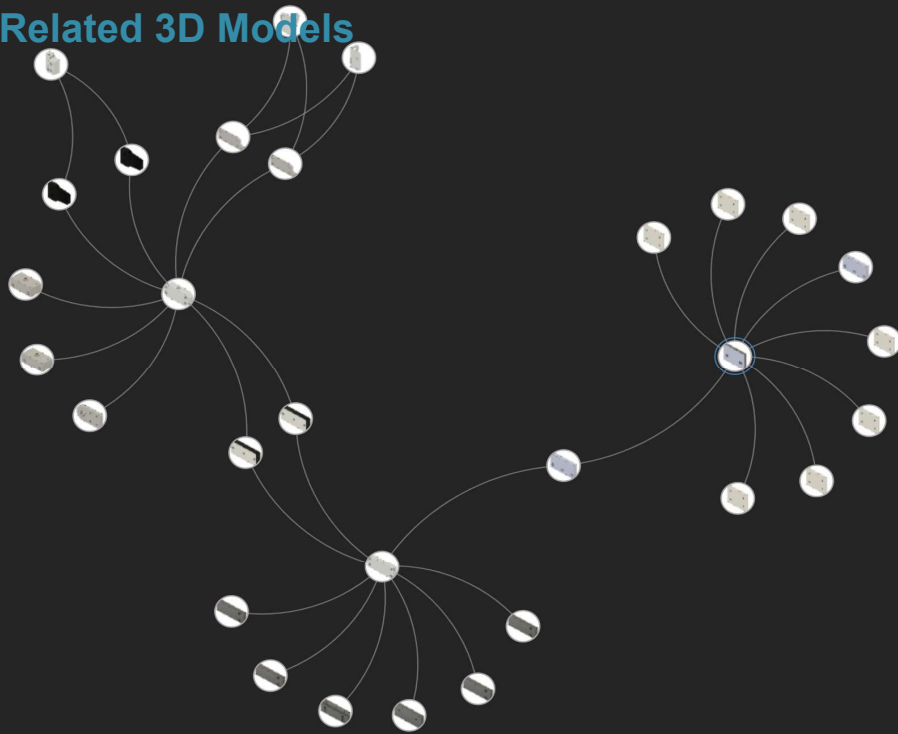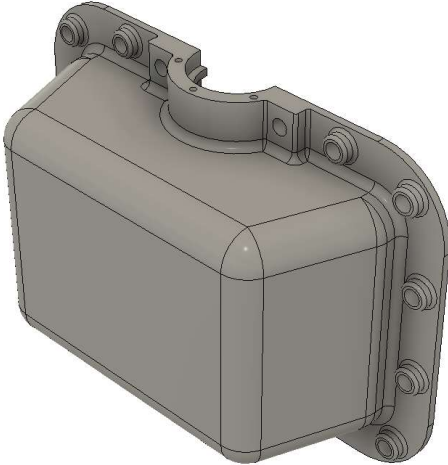
Graph of Related 3D Models
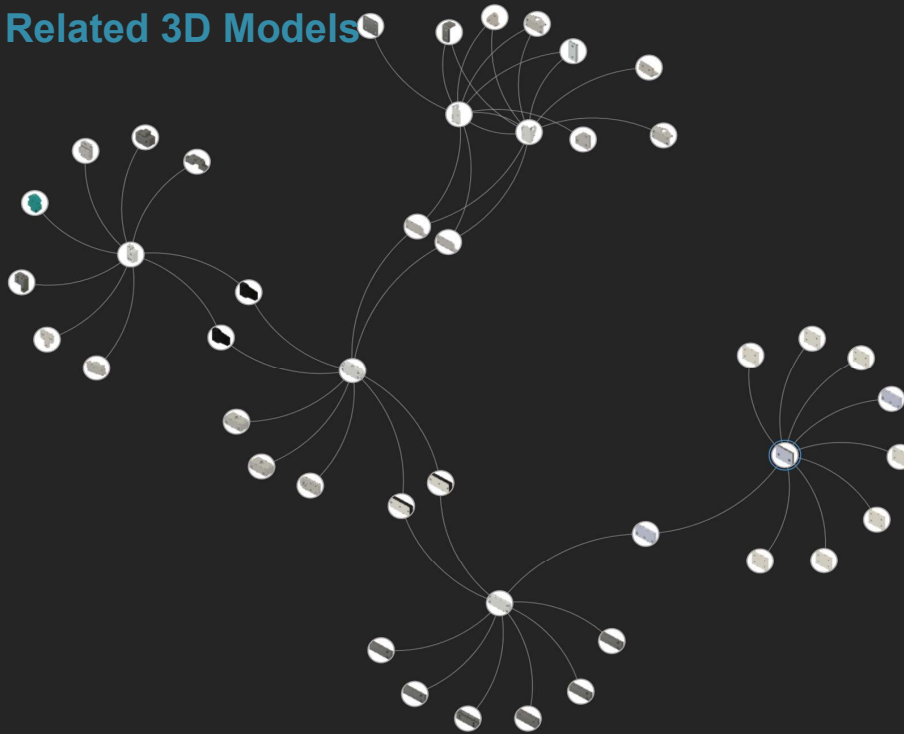
Manual Annotation of 3D Model Datasets

A little army of 10 dedicated students (Mar 1st – May 15th 2020)

Goal is 10,000 3D Models tagged at least twice

25

Problem 2:

Finding Capable Manufacturing Services

Building an Open Knowledge Network Graph
Connecting 3D Model Design Data with Manufacturing Services Data

MOKN
(pronounced as moken)
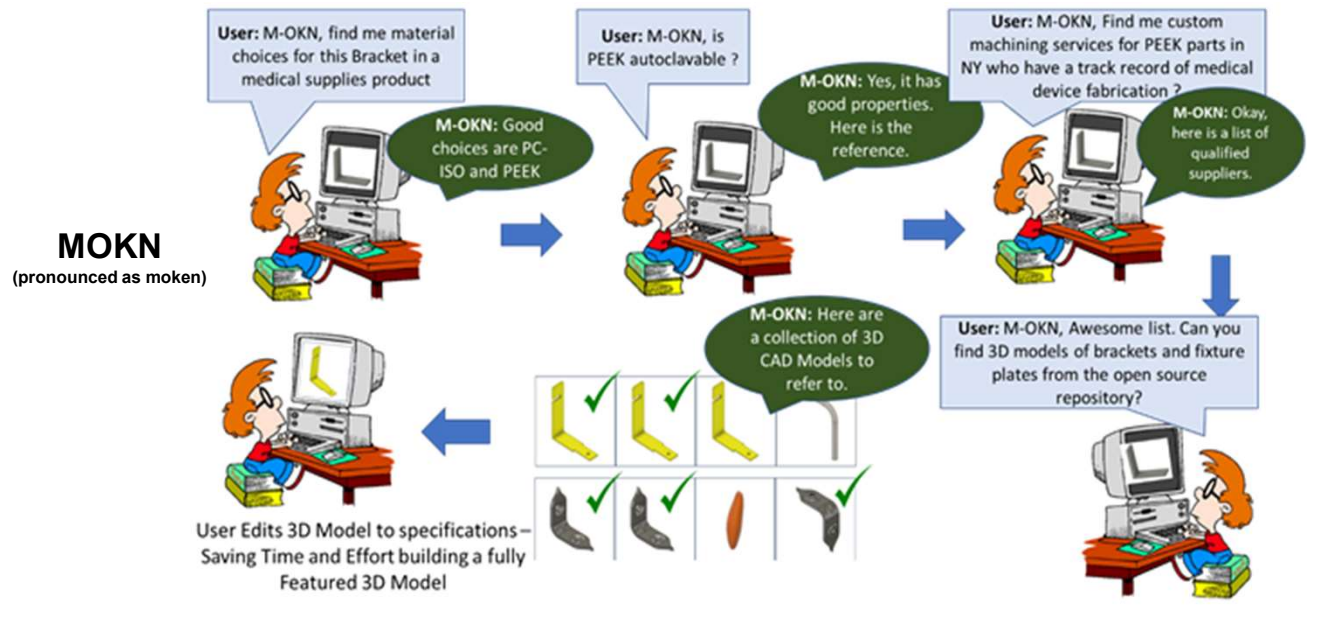
What would it take to build these collaborative interactions?

☐ **Joint Embedding of 3D Model and Text Data and more…**

☐ **Named Entity Recognition (NER) for Domain Specific Knowledge**

☐ **An Updated List of Manufacturing Service Capabilities across USA**

☐ **Address Privacy Concerns & Unavailable Data Provenance**

☐ **Trust and Reputation of Service Providers**

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Collecting Manufacturing Services & Capabilities Raw Data

Across 22K+ small job manufacturers across the USA
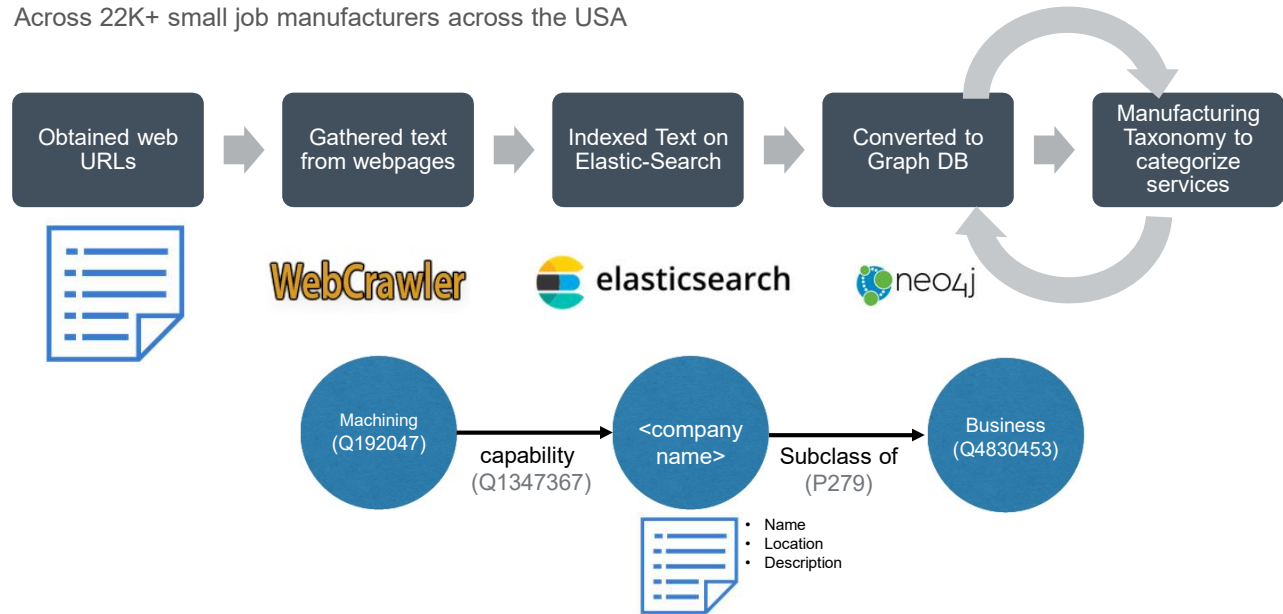
An Initial Graph Connecting Manufacturing Services

Sub-Graph with 3300 nodes with 4500+ connections

https://kumu.io/starlyb/mokn-services

A Text based Domain Specific Services Search

22,000+ Manufacturing Service Companies in USA and a bit of Canada

https://mfgnetwork.herokuapp.com/

31

Solution to address Challenges

SEARCH ENGINE OPTIMIZATION (SEO) specific to Manufacturing Domain

CAN WE GET MANUFACTURERS TO **EMBED MANUFACTURING SPECIFIC VOCABULARY** THAT **PROJECTS CAPABILITIES** & MARKETS SERVED

32

Analyzing Product Design & Manufacturing Content on the Web
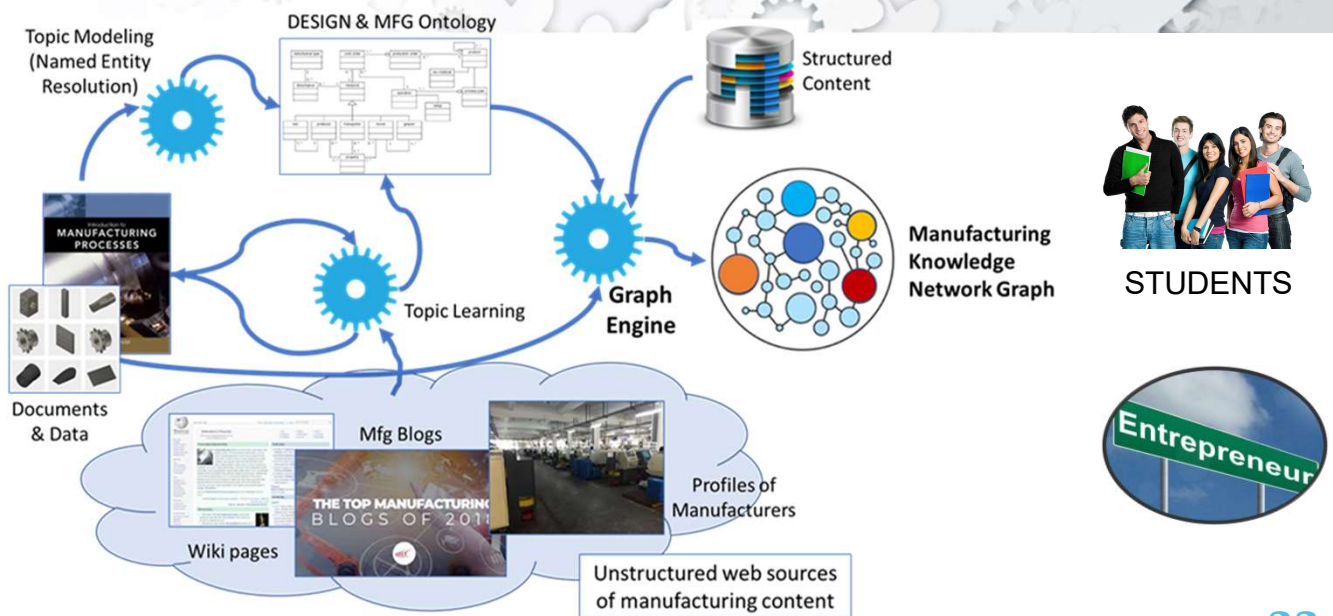
Human Annotation of Manufacturing Index Words

Link Manufacturing Text to Wikidata / DBpedia

GOAL: Use DNN to Analyze More than 5M+ Manufacturing Research Abstracts/Blogs/Articles
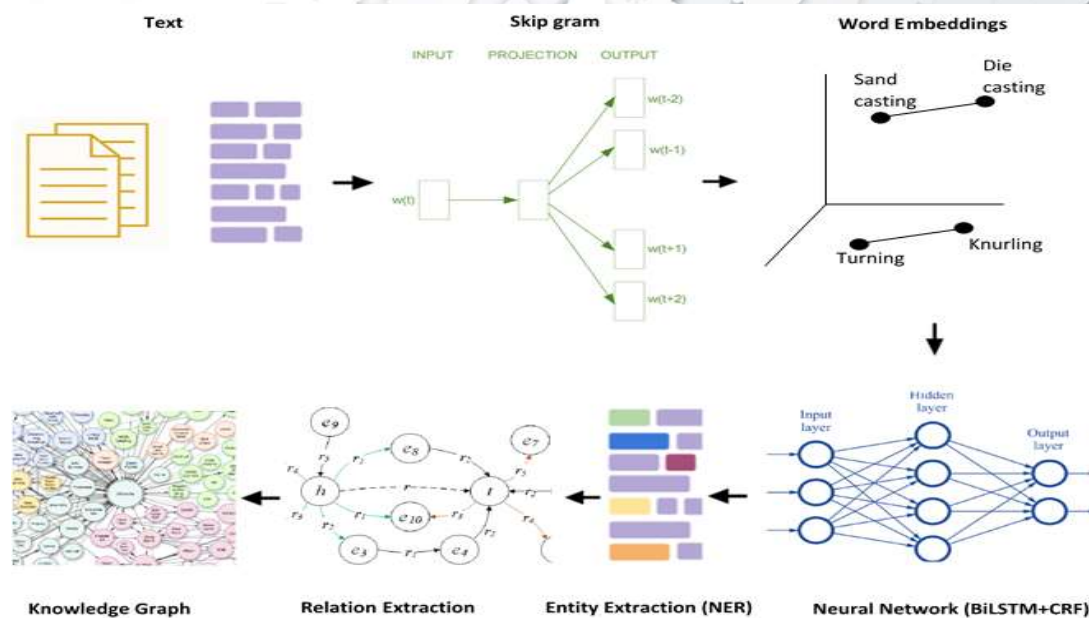
35

Community Help

Collaboration

With Government Labs
With Industry R & D
With Small Manufacturers

MANUFACTURING ONTOLOGY	A Manufacturing specific Named Entity Recognition (NER)	KNOWLEDGE GRAPH ANALYTICS	Manufacturing Extension Partnership (MEP)	Software & Infrastructure Assistance

36

Future of Manufacturing

Collaborative AI for Personalized Products

Service Marketplaces

Automated Production with Local Distributed Production

37

Thank you

Feedback and Comments are always welcome

http://www.dimelab.org
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NSF OAC CESER #1812687 – FabWave Repository
NSF CISE CNS #1764025 – Smart Marketplaces (w. PI: Kemafor Ogan)
NSF ENG ERC #1840363 – Design by Anyone and Build Anywhere (Planning Grant)
NSF OIA #1937043 – Phase I - Open Knowledge Graph in Manufacturing

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