Universität Stuttgart
Institut für Automatisierungstechnik
und Softwaresysteme

Entwicklung eines Ontologie-Modells für die semi-automatisierte Datenintegration von Sensorkomponenten in Produktionssystemen

Abschlussvortrag

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Studiengang: Elektromobilität

Supervisor: Yuchen Xia

Motivation

Meta-Beschreibung von einer technischen Komponente

[1]

[2]

- Erstellung einer digitalen Repräsentation von physischen Komponenten, um die Informationszugriff zu erleichtern:
  - Z.B.:
    - Für die Wartungsarbeit (Zielanwender: **Integration- und Wartungsfachkraft**)
    - Zur Einsicht, Evaluierung und einfache Diagnose von Asset (Zielanwender: **Manager**)

Motivation

Meta-Beschreibung von einer technischen Komponente

- Integration und Wartung in Produktionssystemen
  - Schlüsseldaten in technischer Spezifikation

[3]

- Bedeutung der Daten in Informationsmodellen
  - Äquivalente Datenmerkmale
    -- „Scanning angle“, „Scan angle“
    -- „Field of view“, „Viewing window“
  - Unterschiedliche Datenmerkmale
    -- „Current measurement“
      A. Aktuelle Messung ?
      B. Messung für Strom ?

Problem

Informationsmodelle verwenden unterschiedliche Vokabular

Technische Spezifikationen für Sensorik

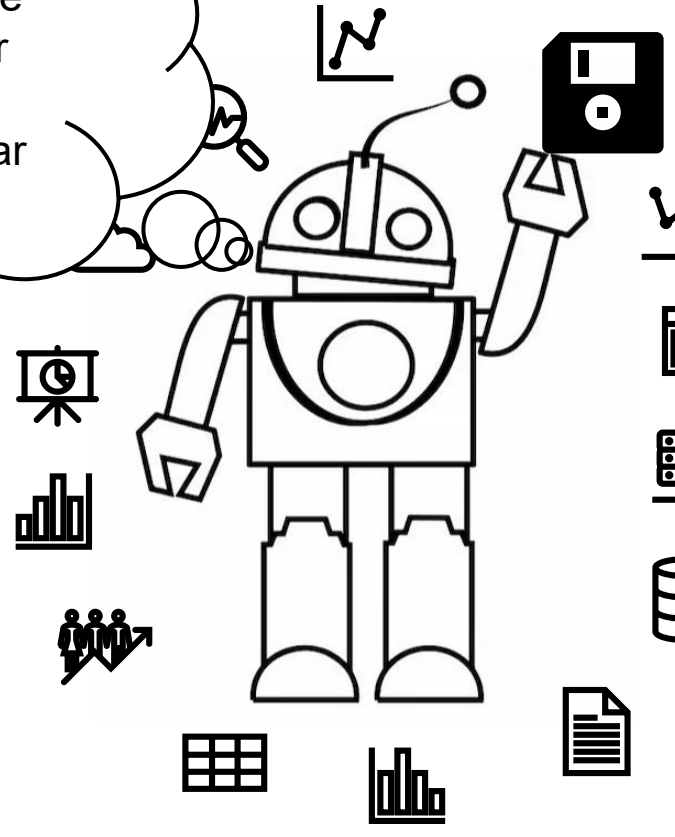
Datenmerkmale mit gleicher/äquivalenter Bedeutung

Hersteller A	Hersteller B	Hersteller C
2D LASER SCANNER	2D LIDAR SENSORS	Safety Laser Scanner	Safety-related Laser Scanners
Scanning angle 270°	Field of view 200°	Detection range 275°	Viewing window 275°
Ambient operating temperature	Ambient operating temperature	Operating Temperature	Operating temperature
Light source Infrared (850 nm)	--	Wave Length	Wavelength
⋮	⋮	⋮	⋮

Die Austauschbarkeit von Daten mit der gleichen Semantik

Forschungsfrage

Wie kann Maschine die Metadaten der unterschiedlichen Sensoren skalierbar verwalten?

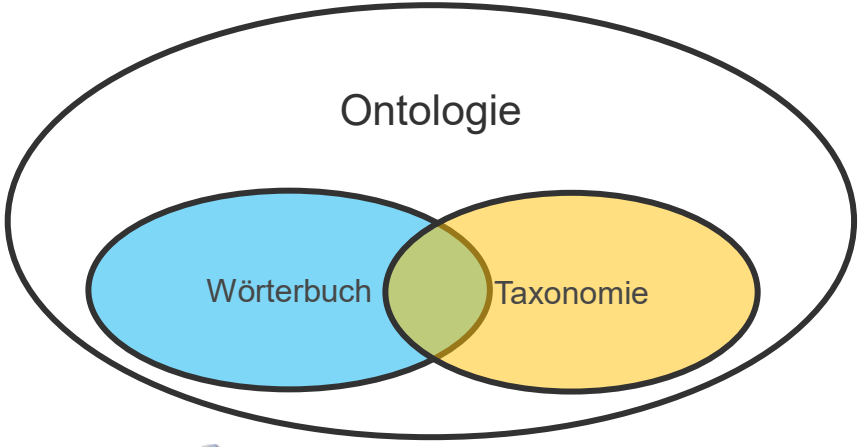


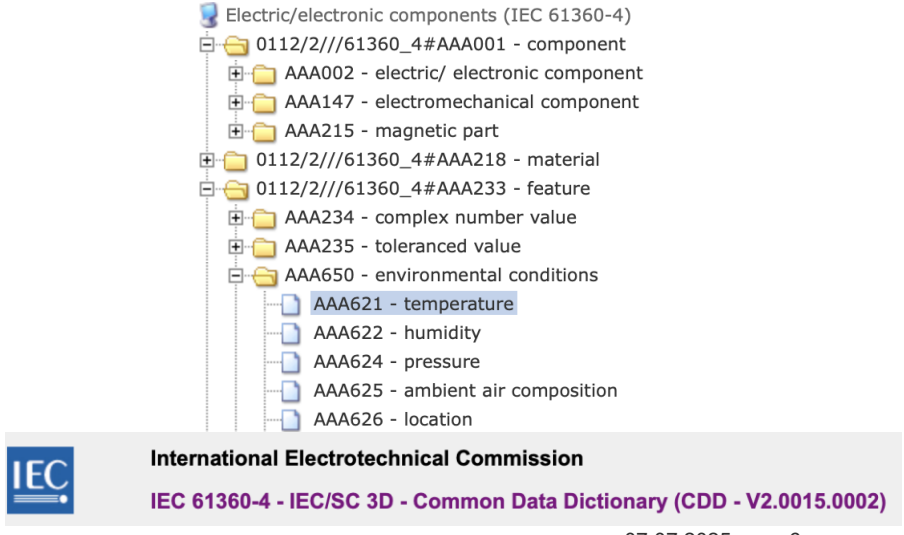
Wie kann Maschine die Bedeutung der Sensoren-Parameter verstehen?

Wie kann die Semantik untergebracht werden?

Ontologisches Modell

- Wörterbuch, Taxonomie
- Ontologie
  - Verwaltung von Daten-Konzepten
  - Beziehung zwischen Daten
  - Klare Definition der Begriffe
  - Skalierbar
  - Als Graph Database gespeichert werden kann
  - die Daten mit Query Language verwalten und abrufen
- …





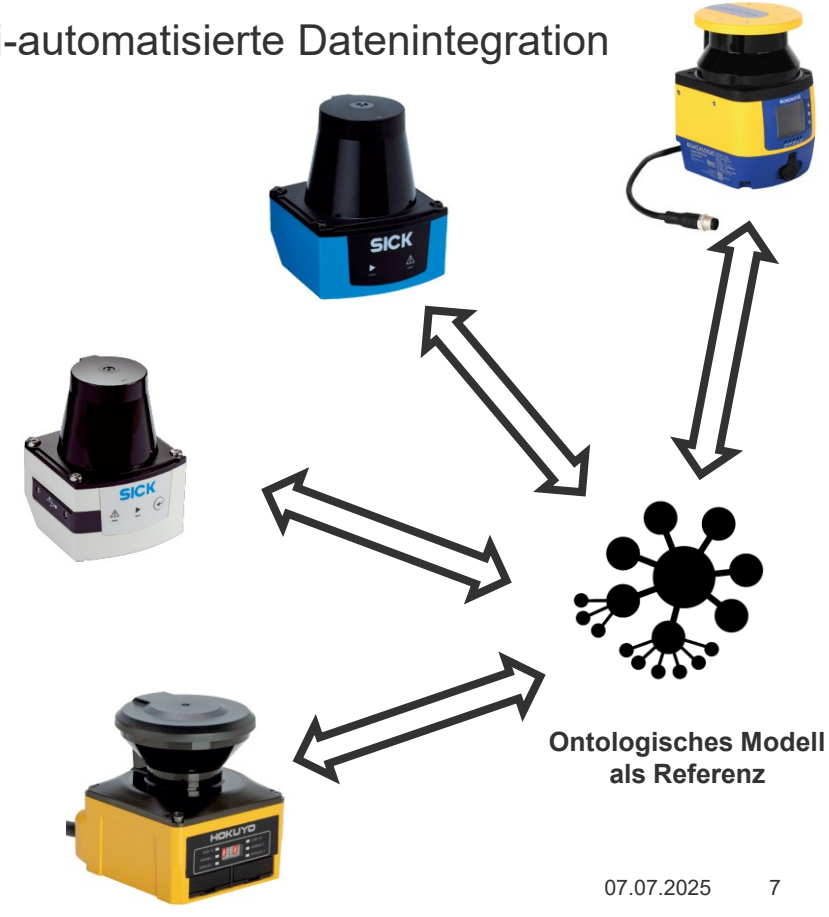
Heterogene Daten in einheitliche Format transformieren

Mit expliziter Semantik

Entwicklung eines Ontologie-Modells für die semi-automatisierte Datenintegration

1. Entwicklung eines Ontologie-Modells
   - Die Datenmerkmale in der Ontologie werden semantisch annotiert

2. Semi-automatisierte Datenintegration
   - Um den manuellen Aufwand bei der Datenintegration zu sparen



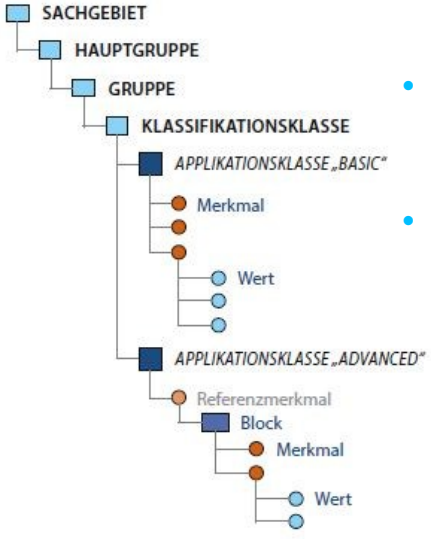
Entwicklung eines Ontologie-Modells

Verfügbare Merkmale-Definition aus **Normen**

Industriegebiet

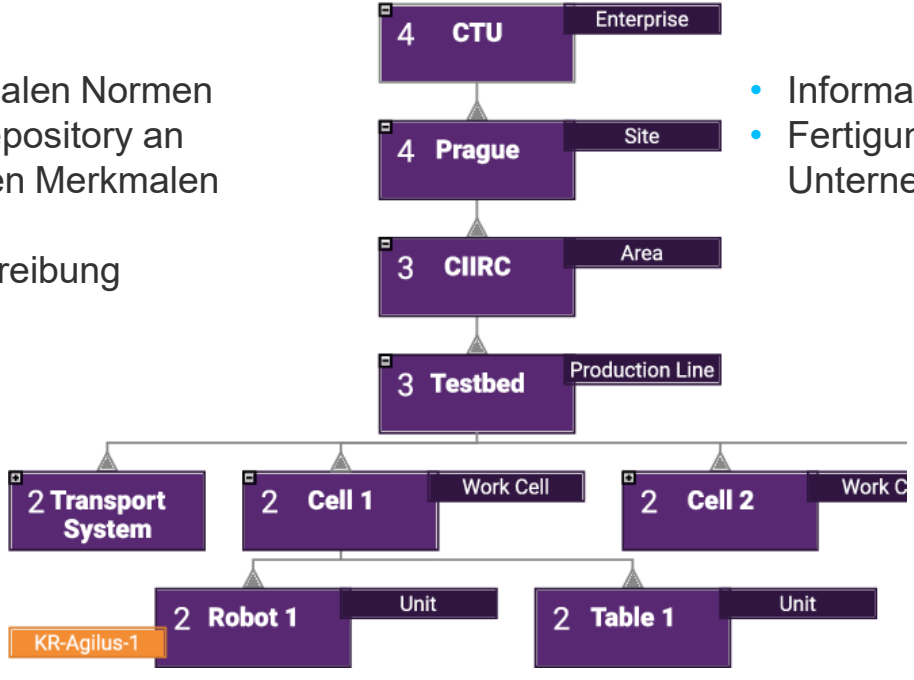
ECLASS

IEC-62264



[4]

- Auf internationalen Normen basierende Repository an beschreibenden Merkmalen
- Eindeutige Konzeptbeschreibung

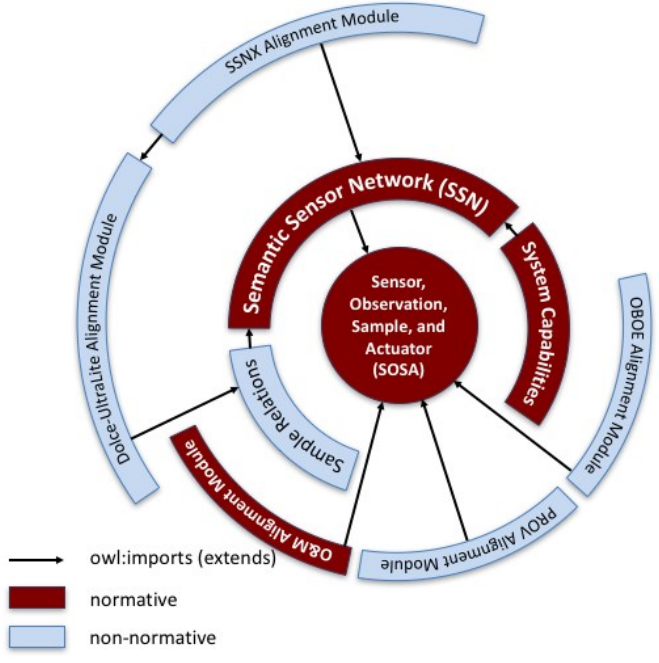


[5]

- Informationsaustausch
- Fertigungsnahe Unternehmensbereiche

Entwicklung eines Ontologie-Modells

Reuse der Ontologie als Quelle der semantischen Daten **aus Ontologien**



Quelle [6]

- Verfügbare Ontologien
  - Domänenspezifische Ontologie
    - SSN (Semantic Sensor Network)
    - SOSA (Sensor, Observation, Sample, and Actuator)
  - Generelle Ontologie
    - Dublin Core (DC) Ontology
    - Friend Of A Friend (FOAF) Ontology
    - REPRODUCE-ME Ontology
    - Goodrelations (GC) Ontology
    - Semanticscience Integrated Ontology (SIO)
    - …

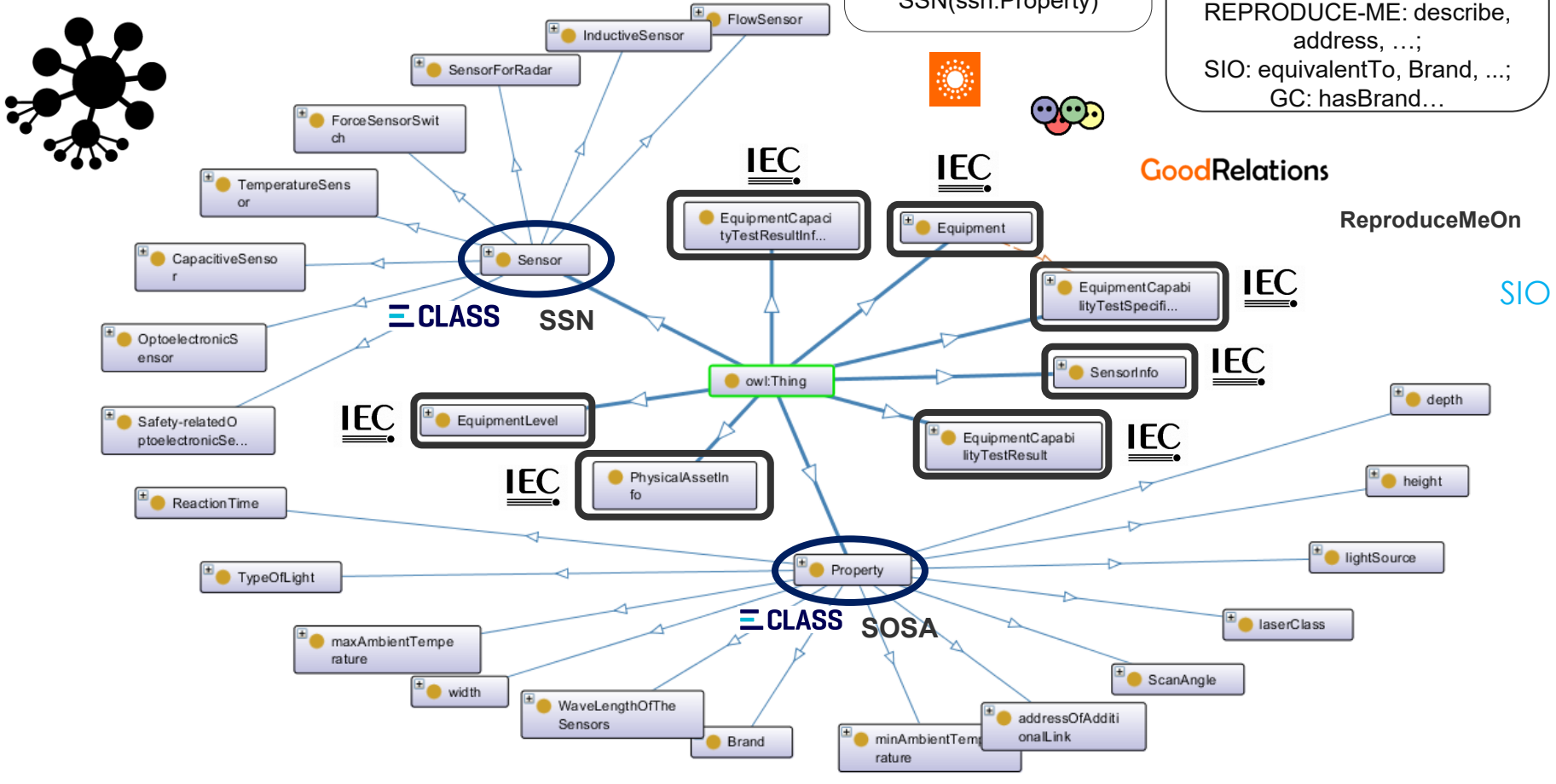

ReproduceMeOn GoodRelations SIO

Entwicklung eines Ontologie-Modells

Ontologisches Modell als Referenz

Classes & Object Properties:
SOSA(sosa:Sensor),
SSN(ssn:Property)

Annotation Properties & Object Properties:
DC: description, …;
FOAF: depection, …;
REPRODUCE-ME: describe, address, …;
SIO: equivalentTo, Brand, ...;
GC: hasBrand…



Semi-automatisierte Datenintegration

Um manuellen Aufwand zu sparen

Entwicklung eines Ontologie-Modells für die semi-automatisierte Datenintegration

1. Entwicklung eines Ontologie-Modells
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2. Semi-automatisierte Datenintegration
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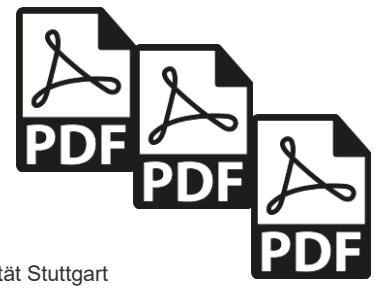
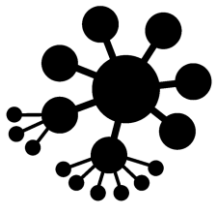


Schlüssel-Wert-Paare



Das entwickelte Ontologie-Modell

Semi-automatisierte Datenintegration

Wie sieht die Quelldaten aus

Ordering information

Type	Part no.
TIM551-2050001	1060445

Other models and accessories → www.sick.com/TiM5xx

Detailed technical data

Features

Field of application	Outdoor
Light source	Infrared (850 nm)
Laser class	1, eye-safe (EN 60825-1 (2007-10))
Aperture angle	270°
Scanning frequency	15 Hz
Angular resolution	1°
Operating range	0.05 m ... 10 m
Max. range with 10 % reflectivity	8 m

Performance

Response time	Typ. 67 ms
Detectable object shape	Almost any
Systematic error	± 60 mm
Statistical error	20 mm

Interfaces

Ethernet	✓
USB	✓, micro USB
Function	AUX, parameterization
Switching inputs	0 (PNP)
Switching outputs	1 (PNP, "SYNC"/"device ready")
Optical indicators	2 LEDs (ON, "device ready")

Mechanics/electronics

Electrical connection	1 x "Ethernet" connection, 4-pin M12 female connector 1 x connection "Power/Synchronization output" 5-pin, M12 male connector 1 x Micro USB female connector, type B
Operating voltage	9 V DC ... 28 V DC
Power consumption	3 W

Housing color	Gray (RAL 7032)
Enclosure rating	IP 67 (EN 60529/A1:2000-02)
Protection class	III (EN 60950-1/A11 (2009-03))
Weight	250 g, without connecting cables
Dimensions (L x W x H)	60 mm x 60 mm x 86 mm

Ambient data

Object remission	4 % ... > 1,000 % (reflectors)
Electromagnetic compatibility (EMC)	EN 61000-6-3 (2007-01) / EN 61000-6-2 (2005-08)
Vibration resistance	EN 60068-2-6 (2008-02)
Shock resistance	EN 60068-2-27 (2009-05)
Ambient operating temperature	–25 °C ... +50 °C
Storage temperature	–40 °C ... +75 °C
Ambient light immunity	80,000 lx

General notes

Note on use	Not suitable for personnel protection

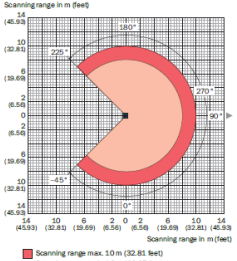
Classifications

ECl@ss 5.0	27270990
ECl@ss 5.1.4	27270990
ECl@ss 6.0	27270913
ECl@ss 6.2	27270913
ECl@ss 7.0	27270913
ECl@ss 8.0	27270913
ECl@ss 8.1	27270913
ECl@ss 9.0	27270913
ETIM 5.0	EC002550
ETIM 6.0	EC002550
UNSPSC 16.0901	46171620

Semi-automatisierte Datenintegration

Wie sieht die Quelldaten aus

Operating range diagram



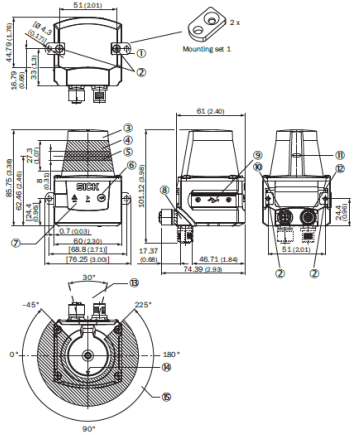
Scanning range max. 1.0 m (32.81 feet)
Scanning range typical 8 m (26.25 feet)
for objects up to 10 % remission

Recommended accessories

Other models and accessories → www.sick.com/TiM5xx

	Brief description	Type	Part no.
Mounting brackets and mounting plates			
	Mounting kit with sun shade/weather protection	Mounting kit	2062398
Plug connectors and cables			
	Head A: female connector, M12, 5-pin, straight, A-coded Head B: cable Cable: shielded, 5 m	Connecting cable (female connector - open)	6026159
	Head A: male connector, M12, 4-pin, straight, D-coded Head B: male connector, RJ45, 8-pin, straight Cable: Ethernet, suitable for refrigeration, shielded, 5 m	Connection cable (male connector-male connector)	6050200
	Head A: male connector, M12, 4-pin, straight, D-coded Head B: male connector, RJ45, 8-pin, straight Cable: Ethernet, drag chain use, PUR, shielded, 5 m	SSL-2J04-G05ME	6034415

Dimensional drawing (Dimensions in mm (inch))



① 2 x straight plates with M3 x 4 mm screw (included in delivery)
② M3 threaded mounting hole, 2.8 mm deep (blind hole thread)
③ Optical hood
④ Receiving range (light inlet)
⑤ Transmission range (light emission)
⑥ Push-button (no function)
⑦ Red and green LED (status displays)
⑧ Swivel connector unit
⑨ Micro USB female connector, type B
⑩ Connection "Power/Synchronization output" 5-pin, M12 male connector
⑪ Marking for the position of the light emission level
⑫ "Ethernet" connection, 4-pin M12 female connector
⑬ Area in which no reflective surfaces are allowed for mounted devices
⑭ Bearing marking to support alignment (90° axis)
⑮ Aperture angle 270° (scanning angle)

Online data sheet

SICK AT A GLANCE

SICK is one of the leading manufacturers of intelligent sensors and sensor solutions for industrial applications. A unique range of products and services creates the perfect basis for controlling processes securely and efficiently, protecting individuals from accidents and preventing damage to the environment.

We have extensive experience in a wide range of industries and understand their processes and requirements. With intelligent sensors, we can deliver exactly what our customers need. In application centers in Europe, Asia and North America, system solutions are tested and optimized in accordance with customer specifications. All this makes us a reliable supplier and development partner.

Comprehensive services complete our offering: SICK LifeTime Services provide support throughout the machine life cycle and ensure safety and productivity.

For us, that is "Sensor Intelligence."

Overview

More than just object detection: The TiM5xx 2D LiDAR sensor is a non-contact ranging solution within the TiM series from SICK. Thanks to its HDDM technology, the TiM5xx is able to monitor large areas in indoor and outdoor applications – regardless of the surface or ambient light. Enclosed in a compact, rugged housing, the TiM5xx provides accurate measurement data from the scanned surface, making it possible to determine additional information such as the size and shape of objects. The TiM5xx is flexible for use in a variety of industrial applications as well as in building automation. The integrated Ethernet interface makes for easy implementation and remote maintenance. The TiM5xx is an efficient solution for stationary use as well as for use on automated guided vehicles (AVG) and in other mobile applications.

At a glance

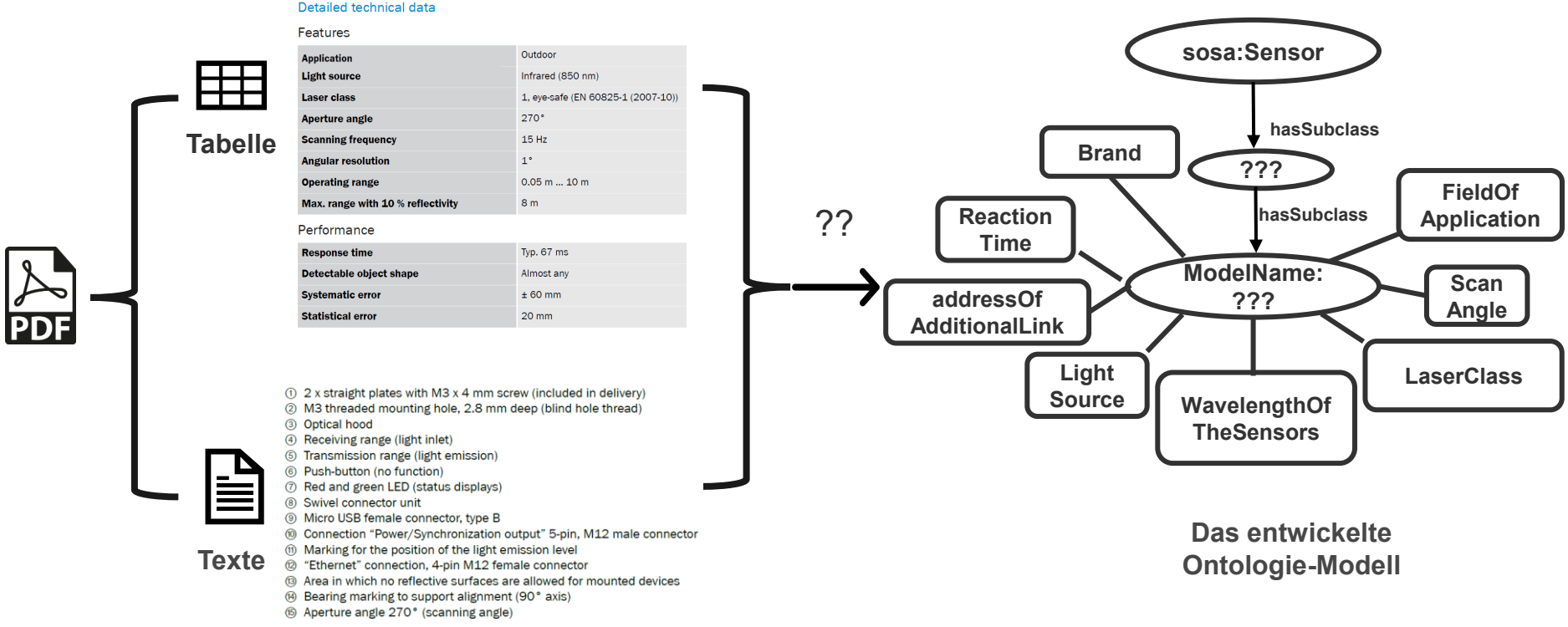
- Monitoring area of up to 1,470 m² with just one sensor
- High ambient light tolerance due to HDDM technology
- Rugged housing with up to an IP 67 enclosure rating
- Low power consumption (typ. 4 W)
- Compact design with a housing height of just 86 mm maximum
- Integrated Ethernet interface
- Long sensing range of up to max. 25 m
- Industry-standard design and M12 male connector

SICK AG | Waldkirch | Germany | www.sick.com

Sensor Intelligence.

Semi-automatisierte Datenintegration

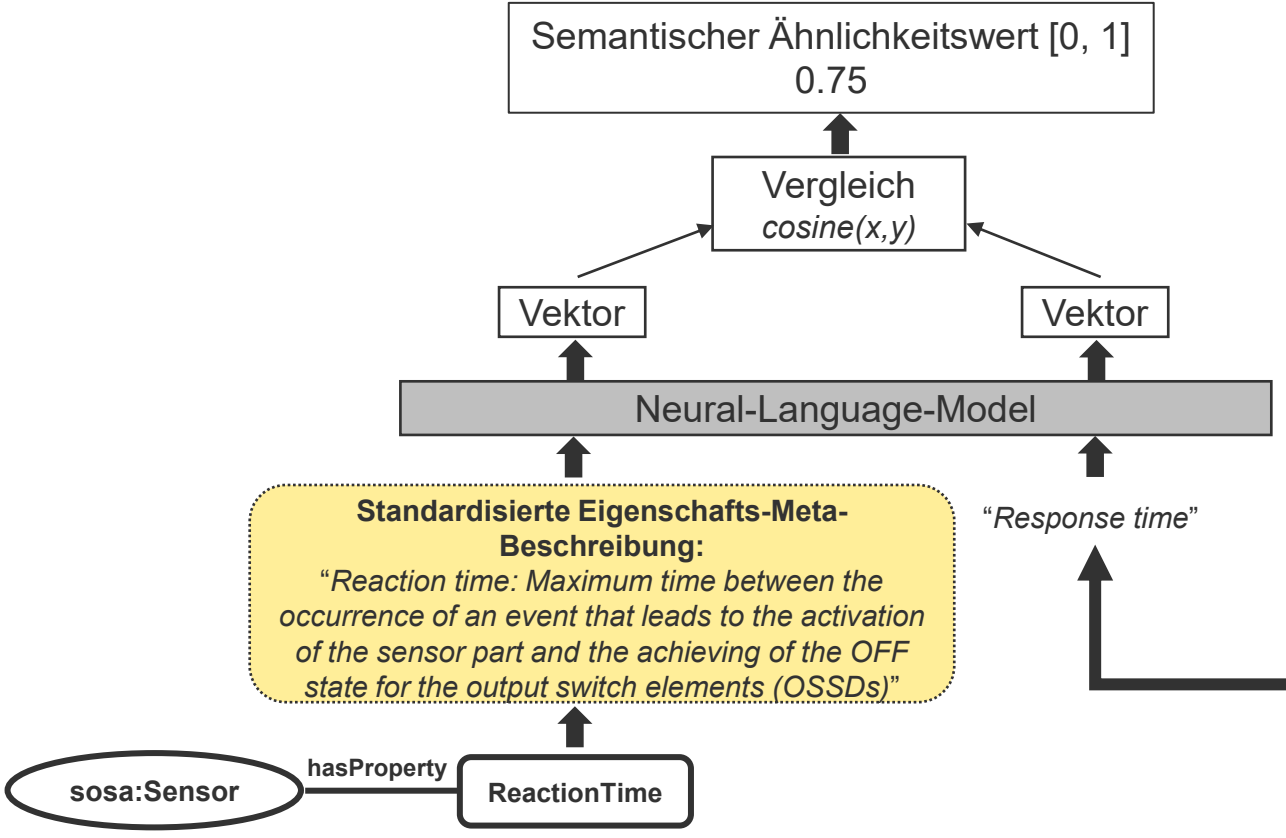
Daten-Transformation



Wie kann das Vorgang automatisiert werden?

Durch Einsatz von Natural-Language-Processing-Methode

Ermittlung von semantischen Ähnlichkeit mit Neural-Language-Model



Detailed technical data

Features

Field of application	Outdoor
Light source	Infrared (850 nm)
Laser class	1, eye-safe (EN 60825-1 (2007-10))
Aperture angle	270°
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Angular resolution	1°
Operating range	0.05 m ... 10 m
Max. range with 10 % reflectivity	8 m

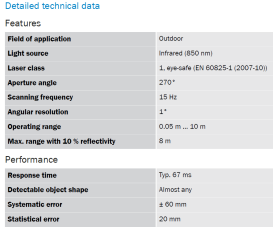
Performance

Response time	Typ. 67 ms
Detectable object shape	Almost any
Systematic error	± 60 mm
Statistical error	20 mm

Quelle: [12]

Semi-automatisierte Datenintegration mit NLP-Methode

Daten-Transformation von **Tabelle** zum Ontologiemodell


Detailed technical data

Features

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Neural Language Model

Tabelle

Schlüssel-Wert-Paare

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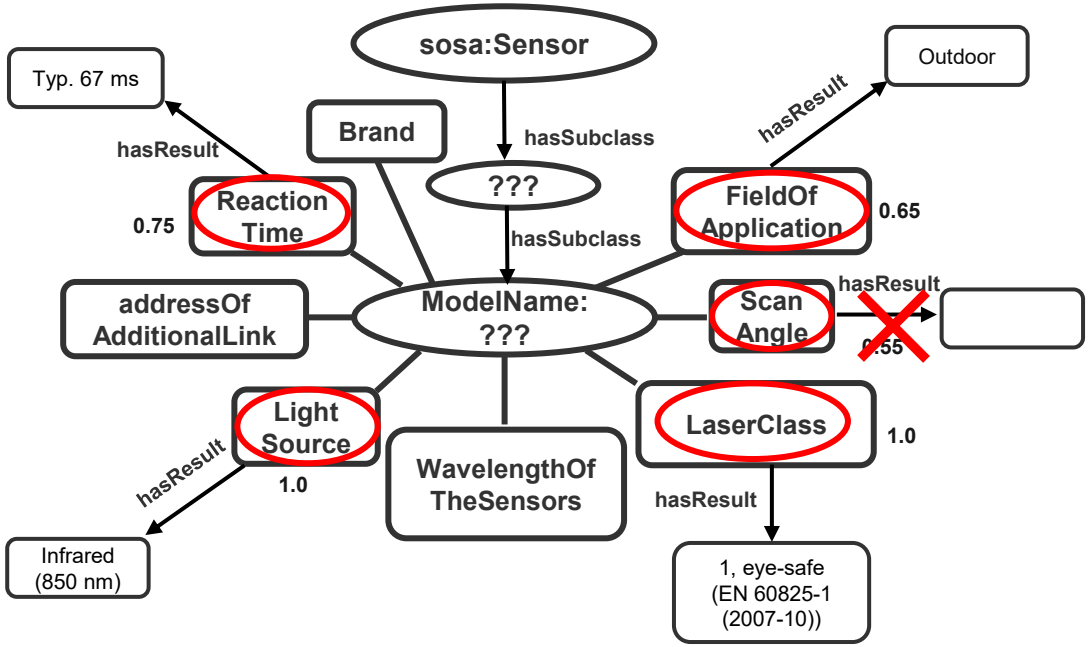
Similarity ≥ 0.65



Semi-automatisierte Datenintegration

Daten-Transformation von **Textsatz** zum Ontologiemodell (3 Methode)

Ähnlichkeit: 0.55

Andere Methode?

Detailed technical data

Features

Application	Outdoor
Light source	Infrared (850 nm)
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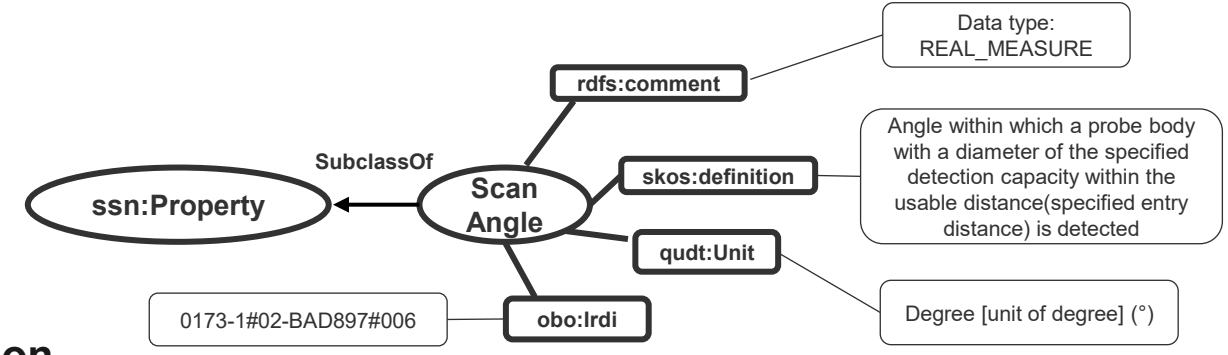
⑬ Area in which no reflective surfaces are allowed for mounted devices
⑭ Bearing marking to support alignment (90° axis)
⑮ Aperture angle 270° (scanning angle)

Semi-automatisierte Datenintegration

Daten-Transformation von **Textsatz** zum Ontologiemodell (3 Methode)



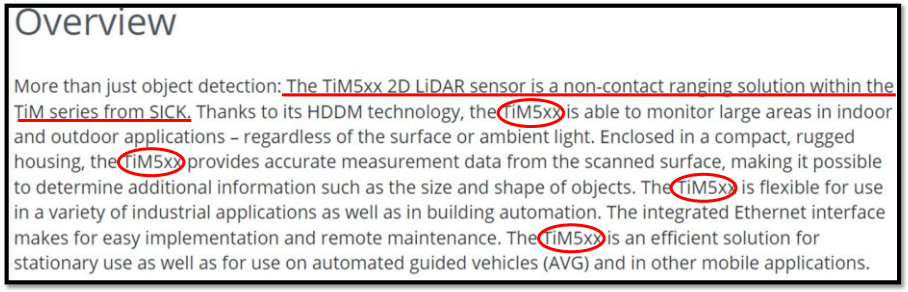
1. Tokenization

"Aperture angle 270° (scanning angle)"

Token Nr.	0	1	2	3	4	5	6	7
Text	Aperture	angle	270	°	(	scanning	angle	)
Lemma	aperture	angle	270	°	(	scan	angle	)
POS	NOUN	NOUN	NUM	NOUN	PUNCT	NOUN	NOUN	PUNCT
Dep	compound	ROOT	nummod	appos	punct	compound	appos	punct

Semi-automatisierte Datenintegration mit NLP-Methode

Daten-Transformation von **Textsatz** zum Ontologiemodell



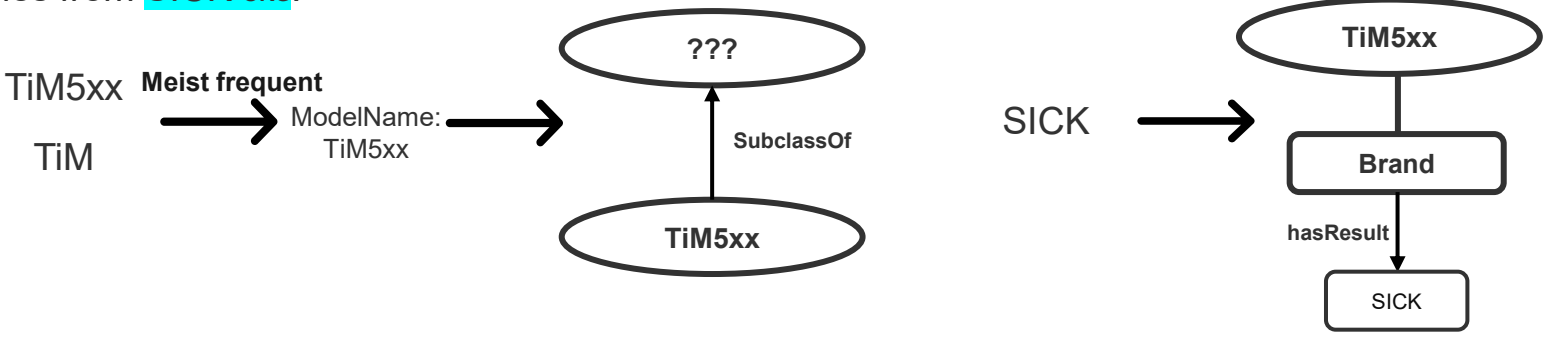
Natural Language Processing Tool

→ spaCy

Schlüssel-Wert-Paare

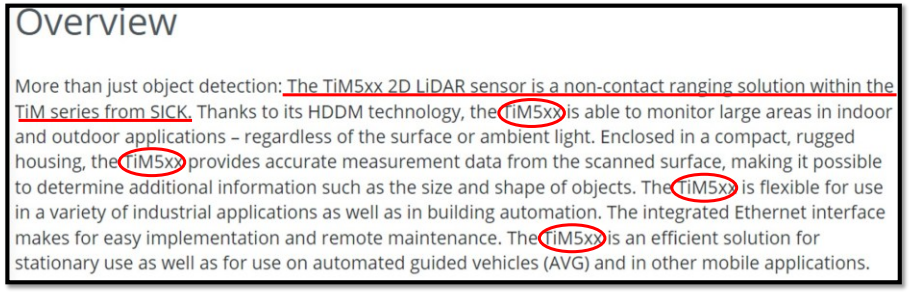
2. Named Entitiy Recognition

The TiM5xx *PRODUCT* 2D laser scanner is a non-contact ranging solution within the TiM *PRODUCT* series from SICK ORG.



Semi-automatisierte Datenintegration mit NLP-Methode

Daten-Transformation von **Textsatz** zum Ontologiemodell



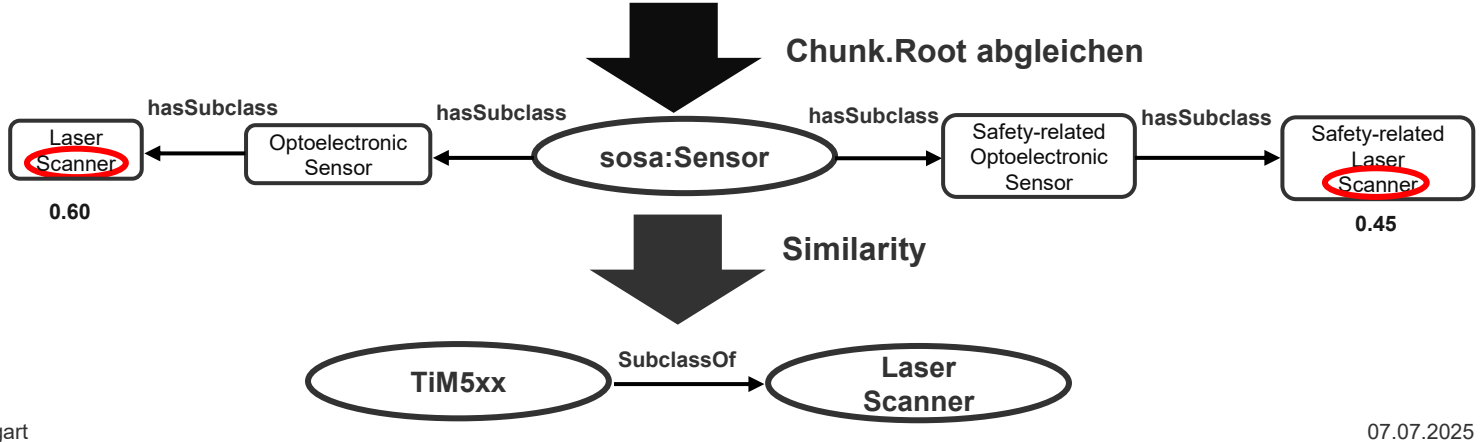
Natural Language Processing Tool

→ spaCy

Schlüssel-Wert-Paare

3. Dependency Parsing: *„Noun-Chunk“*

The TiM5xx 2D laser scanner is a non-contact ranging solution within the TiM series from SICK.



Ergebnisse

NLP Neural Model VS String Matching

- Die Datentransformation von Datenmerkmale aus **demselben** Hersteller (SICK Sensor)
- 6 Technische Spezifikationen (PDF) von 2 Sensortypen, davon:
  - 3 Laser Scanner
  - 3 Safety-related Laser Scanner

	Neural Language Model		String Matching (zum Vergleich)	
Merkmale aus Ontologie	**Precision**	**Recall**	**Precision**	**Recall**
ModelName	83.3%	83.3%	0%	0%
SubClassOf	50%	50%	0%	0%
Brand	83.3%	83.3%	0%	0%
addressOf AdditionalLink	66.7%	66.7%	0%	0%
FieldOfApplication	50%	50%	16.7%	16.7%
ReactionTime	100%	100%	33.3%	0%
ScanAngle	66.7%	66.7%	0%	0%
LaserClass	100%	100%	100%	100%
LightSource	100%	100%	100%	100%
WaveLengthOfThe Sensors	100%	100%	83.3%	0%
Insgesamt mit aller Merkmale	**80%**	**69.4%**	**33.3%**	**5%**

Ergebnisse

Generalisierbarkeit

- SICK VS andere 8 Marke
  - Leica, BANNER, LEUZE, OMRON, PHARO, HOKUYO, ROCKWELL, DATALOGIC
- 15 Technische Spezifikationen:
  - 4 Laser Scanner,
  - 11 Safety-related Laser Scanner

Designed for use on or around dangerous areas, accesses, and hazardous points, the SafeZone 3 is the next generation safety laser scanner platform that features high definition distance measurement scanning technology. This scanning technology improves the

	SICK		Andere Marke	
Merkmale aus Ontologie	**Precision**	**Recall**	**Precision**	**Recall**
ModelName	83.3%	83.3%	44.4%	44.4%
SubClassOf	50%	50%	66.7%	66.7%
Brand	83.3%	83.3%	66.7%	66.7%
addressOf AdditionalLink	66.7%	66.7%	44.4%	44.4%
FieldOfApplication	50%	50%	0	0
ReactionTime	100%	100%	77.8%	60%
ScanAngle	66.7%	66.7%	55.6%	50%
LaserClass	100%	100%	77.8%	44.4%
LightSource	100%	100%	77.8%	100%
WaveLengthOfThe Sensors	100%	100%	100%	100%
Insgesamt mit aller Merkmale	**80%**	**69.4%**	**60.4%**	**48.2%**

Zusammenfassung und Ausblick

- Automatisierte Datentransformation
  - **Zeit** und **Kosten** sparen, indem die heterogenen Daten in einer einheitlichen Form automatisch transformiert werden. (Semantisch wohl-definiert)
  - Für technische Spezifikation von gleicher Hersteller:
    - circa 80% in Precision und 70% in Recall
    - Zeit zu suchen ist dabei gespart, aber man sollte die Ergebnisse noch überprüfen. (**semi-automatisiert**)
  - **Generalisierbarkeit** (mit anderen hersteller-spezifischen Dokumenten):
    - circa 60% in Precision und 50% in Recall

- Ausblick
  - Softwareprodukt entwickeln, um die Datenintegration zu erleichtern.

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Vielen Dank!

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Quelle

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