CONTROLINSTEEL

Systematic analysis of advanced automation and control solutions in EU funded research projects of the last decades

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2021-08 – European Steel Technology and Application Days (ESTAD)



















1. Introduction

- 2. Analysis based on semantic tools **3.** Preliminary Results





1. Introduction





About the project

ControllnSteel is a dissemination activity focusing advanced automation and control

We selected around 45 former RFCS research projects for a scientific analysis

Mission goals

I. Analyze and understand dynamics of the problem-, solution- and impact space which also includes **barriers** and **issues**, as well as **physical interaction channels** 2. Perform dissemination events, e.g. conference sessions and workshops to

3. Provide a roadmap for future research



effectively distribute knowledge from and about these former projects



Scientific approach to controlled vocabulary

Synonyms



From: ESL Forums, eslforums.com, 2019

Taxonomies

Degree of complexity ------

the second s		BLOOM'S TAXONOMY DIGITAL PLANNING VERBS							
REMEMBERING	UNDERSTANDING	APPLYING	ANALYZING	EVALUATING	CREATING				
350	+				T				
Copying	Annotating	Acting out	Calculating	Arguing	Blogging				
Defining	Tweeting	Articulate	Categorizing	Validating	Building				
Finding	Associating	Reenact	Breaking Down	Testing	Animating				
Locating	Tagging	Loading	Correlating	Scoring	Adapting				
Quoting	Summarizing	Choosing	Deconstructing	Assessing	Collaborating				
Listening	Relating	Determining	Linking	Criticizing	Composing				
Googling	Categorizing	Displaying	Mashing	Commenting	Directing				
Repeating	Paraphrasing	Judging	Mind-Mapping	Debating	Devising				
Retrieving	Predicting	Executing	Organizing	Defending	Podcasting				
Outlining	Comparing	Examining	Appraising	Detecting	Wiki Building				
Highlighting	Contrasting	Implementing	Advertising	Experimenting	Writing				
Memorizing	Commenting	Sketching	Dividing	Grading	Filming				
Networking	Journaling	Experimenting	Deducing	Hypothesizing	Programming				
Searching	Interpreting	Hacking	Distinguishing	Measuring	Simulating				
Identifying	Grouping	Interviewing	Illustrating	Moderating	Role Playing				
Selecting	Inferring	Painting	Questioning	Posting	Solving				
Tabulating	Estimating	Preparing	Structuring	Predicting	Mixing				
Duplicating	Extending	Playing	Integrating	Rating	Facilitating				
Matching	Gathering	Integrating	Attributing	Reflecting	Managing				
Bookmarking	Exemplifying	Presenting	Estimating	Reviewing	Negotiating				
Bullet-pointing	Expressing	Charting	Explaining	Editorializing	Leading				

From: Blooms Taxonomy, Terry Heick, 2018





Storing knowledge: Mereology

ROLLING MILL

CONTROL STRATEGY

CHANNEL OF INTERACTION



AUTOMATION

DATA

CONTROL STRATEGY

AUTOMATION



ROLLING MILL is part of PLANT ROLL is part of ROLLING MILL DATA is part of AUTOMATION

mereological description.

ontology.

DATA

... this is called a

It is typically done in an



Storing knowledge: Logical combination

ROLLING MILL

CHANNEL OF INTERACTION



AUTOMATION



DATA is part of AUTOMATION and is generated by SENSOR

TEMPERATURE SENSOR

DATA



Industry 4.0 in the mereologic perspective

ROLLING MILL

CHANNEL OF INTERACTION







Cross-Process, Through-process utilization of data One mission objective of Industry 4.0



Further terms of future technologies

ROLLING MILL

CHANNEL OF INTERACTION





Sharing data and optimizing combined control strategies



Visualizing mission of project





DISTRIBUTE KNOWLEDGE "Disseminate"



Examples of taxonomies

Sectors

Audiovisual and Media Defence Energy Financial Food and Drink Industry Government Health

Manufacturing and Supply Chain Nuclear Public Safety Space Telecom Digital Infrastructure

Research Domains

Assurance, Audit, and Certification

Education and Training

CNDROLOGY CONDESSION and CNDROLENSIES

Security and Privacy

Human aspects





European Cybersecurity Taxonomy, from EU webpage, 2019

Shows the approach to map different terminology axis to find systematic interdependencies



2. Analysis based on semantic tools

We want to know which types of problems, is solved effectively by which types of solutions, and generate what types of impacts, by overcoming which type of barriers and issues.

If we know this, we can maximize the overall impact.







Taxonomy for problem space

T1) Aggregate	Туре	Product	Interaction	
Casting	Continuous casting	Slab	physics:thermodynamic	
Furnace	Slab reheating	Slab	physics:thermodynamic	
	Walking bean reheating	Slab	physics:thermodynamic	
	Billet furnace	Billet	physics:thermodynamic	
Logistics	Transport	Slab	logistics:displacement	
Annealing	Continuous annealing	Strip	physics:thermodynamic	
	Bright annealing		physics:thermodynamic	
	Batch annealing		physics:thermodynamic	
Delling	Doughing mill		pyhsics:forming;	
Rolling	Rougning mill	Siab	physics:thermodynamic	
			pyhsics:forming;	
	Finishing mill	Strip	physics:thermodynamic	
			pyhsics:forming;	
	Cold rolling	Strip	physics:thermodynamic	
			pvhsics:forming:	
	Temper rolling	Strip	physics:thermodynamic	
	Plate mill			
Cooling	Cooling	Slab, Strip	physics:thermodynamic	
			chemical:galvanisation,	
Refinement	Hot dip galvanization	Strip	physics:thermodynamic	
			chemical:galvanisation,	
	Electro galvanisation	Strip	physics:thermodynamic	
	Pickling mill	Strip	chemical:etching:	
			chemical: bond:	
	Coating	Strip	physics:adhesion	
			chemical: bond:	
	Foiling	Strip	physics:adhesion	
	Skin pass	Strip	physics:cutting:	
	Scarfing		priyereereatarig,	
	Levelling	Strip	physics:formina:	
Thru-process			jj	
Topical	Descaling	Slab, Strip	physics:evaporation	
•	Flatness	Strip	physics:forming	
	Quality			
	Long			
	Flat			

 \leftarrow

Aggregate





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Idea of ControllnSteel

Problem space









Barriers & issues space

Project 2



Solution space





Impact analysis per project

Example: RFCS SOPROD, because coordinator was the same

Allows to define project by one or multiple points (!)

Automatic Python code that runs on top of our assessment



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Novel approach

Enabling technologies

Customer satisfaction

Worker performance

Worker safety

Emission

Waste

Power

Throughput

Yield

Costs

Defect root cause

Quality

Statistical methods Evolutionary approaches Data analytics Machine learning Hybrid control Multi-agent Convex optimization

3. Preliminary results

Example result: Impact analysis

Quality Yield projects of our selection Costs Root cause Customer satisfaction Emerging technologies focused by how many Waste reduction projects Novel approach Throughput -Power to normalize our axis Emission Worker performance Worker safety

Based on ca. 85% analyzed Shows which impacts were Mathematically, this helps us

Example result: underrepresentation in solution space

EITHER Technique is not helping many problems and was not considered out of good reasons

OR Technique was simply not covered by research

Example: Laurent expansion never actually mentioned,

Example: Bayesian statistiscs has not been "embraced" in steel production research yet, despite massive successes in

Impact flow and quantified barriers

Availability of data

Problem: Rolling

Projects conducted at rolling millQuantification pending

Project website

CONTROLIN STEEL

Modern automation and control solutions are key for successful processes. European Steel Industry has put great efforts into continuous improvement, research and piloting of novel automation solutions for decades. We analyse the previous work and extract a unique roadmap for future automation research, assisting to reach the goals of the green deal and to provide a vision for a new automation era in steel processing....

Events

Deliverables

010 010 100 10

1111

00 00 01

110010

Learn from the past, to conquer the future 11 1110 1010 0100 100 1101 0101 1000 110 1011 0100 1001

Research Fund for Coal and Steel, Grant Agreement No. 899208

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Summary

Project idea

- Dissemination and impact maximization of various RFCS projects in the field of advanced automation in the downstream process chain
- Taxonomical approach to structure four distinct vocabularies for problems, solutions, impact and barriers
- Systematic analysis of all projects with respect to these vocabularies

Dissemination

- Planning and conduction of workshops to foster research in fields with increased impact
- Development of a roadmap for future research in advanced automation for the downstream process chain

Research Fund for Coal & Steel

Thank you for your interest!

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Aknowledgments... ... goto Dr. Alexander Ebel, who broadly introduced semantic techniques at the BFI and who was inspirational in continuing work in these topics.

