Mapping Knowledge Landscapes: Opportunities and Challenges
Background
About me
Pedro Parraguez
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PhD Thesis
A Networked Perspective on the Engineering Design Process:
At the Intersection of Process and Organisation Architectures
WE ARE BEING
CONTROLLED
BY THE RANDOM
OUTCOMES OF A
COMPLEX SYSTEM

Samuel
How did Denmark create a ~140 billion USD giant?

? = novo nordisk + Master Brew
Inspiration

Porcine insulin

Critical technical expertise in production and fermentation

The making of a $140 billion giant
http://www.cnbc.com/id/100426415

An Engineering Systems Perspective...

Focus on interdisciplinary design of engineering systems
Keywords:

• Complexity and Collaboration
• Knowledge/Capability Ecosystem
• Mapping Knowledge Landscapes
DATA-DRIVEN ANALYSES
SYSTEM ARCHITECTURE → PERFORMANCE

CAPABILITY MAPPING

VISUALISATIONS FOR DECISION MAKING SUPPORT
From Counting to Connecting
From Counting to Connecting

“A spreadsheet way of knowledge”

A connected way of knowledge → where relations matter
Capability and knowledge mapping to support recombinant innovation

Logistics

From counting to connecting
[building blocks]

Data-driven

System thinking

Exploration

Understanding

www.netsights.dk
From top-down expert opinions to data-driven insights
From Units to System(s)
From Search to Discovery
From KPI’s to Key Performance Predictors
Science & (open) Data

Challenges and Opportunities of Open Data

“Open data is critical to assure the rigour of research findings”
Why and how this might be relevant for you

Descriptive and Predictive Analytics
Incl. Backcasting, Nowcasting and Forecasting

New possibilities, expectations and goals
e.g. new levels of analysis and questions

Examples...

• Macro trend analysis
• Evaluation and monitoring
• Control of data structure

www.netsights.dk
Mapping Knowledge Landscapes in Practice
Our approach in practice

Net-Sights
Network Insights for Collaborative Sustainable Production

www.netsights.dk
Net-Sights
Network Insights for Collaborative Sustainable Production

www.netsights.dk
Net-Sights

Network Insights for Collaborative Sustainable Production

Finding the right partner

The urgent need for sustainability

www.netsights.dk
Diagrammatic overview of the framework

Success Factors → Mediators → Recommendation

- Technological Closeness
- Relational Closeness
- Geographical Closeness

Target Innovativeness
Initial Technological Maturity
Time and Budget Constraints

Focal Organisation | Other Organisations | Closeness Weight

www.netsights.dk
Overview of interlocking capabilities in Cleantech

- Technology
- Relations
- Geography

Net-Sights

www.netsights.dk
DTU’s Knowledge Landscape

Net-Sights

Network Insights for Collaborative Sustainable Production

www.netsights.dk
DTU as a Complex Engineering System

A socio-technical process of information transformation

**Engineering system**: ‘A class of systems characterized by a high degree of technical complexity, social intricacy, and elaborate processes, aimed at fulfilling important functions in society’ (de Weck et al., 2011, p. 31).
From counting to connecting

Knowledge census

Knowledge landscape

www.netsights.dk
From counting to connecting

Publication types - 2015 - DTU Orbit (13/02/2016)

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From counting to connecting
From counting to connecting
From counting to connecting
[From tables to networks]
Holistic knowledge mapping VS counting
Holistic knowledge mapping VS counting
Holistic knowledge mapping VS counting
DTU Knowledge Landscape
Data-driven network insights

Welcome

This website provides rich interactive visualisations for two important sets of data at DTU: 1) knowledge assets, including publications, projects, activities and the people that produces these knowledge assets. 2) The Interactions of DTU’s departments with external organisations.

The first interactive visualisation (1) shows different views of what we call the knowledge landscape, which includes a map that allows to identify groups of knowledge assets, search and filter by departments and keywords.

The second interactive visualisation (2) shows what we call the inter-organisational landscape, which allows for a network view of the connections between each department and external organisations.

For more information about this tool and its functionalities please visit the help section. To contact the team behind this initiative and other issues please visit our about page.

Baseline network model
Knowledge Landscape

Project(s)  
Participates in

Publication(s)  
Author of

Takes part on

Activity(ies)

www.netsights.dk
Baseline network model

Knowledge Landscape

Department 1
Department 2
Department 3
A networked and systemic perspective

Actual network model with 25,333 entities

DTU’s complex knowledge landscape

www.netsights.dk
Example

- **25,000+** entities
  (Σ of people, projects, publications and activities)

- **73,000+** relationships between the entities
Overall Knowledge Landscape "Dry Labs"
Example: Knowledge clusters and opportunities around diabetes
Electrical Engineering:
e.g. Internal strain estimation for quantification of human heel pad elastic modulus... changes in heel pad elasticity, as seen in e.g. long-distance runners, diabetes patients...

Physics:
e.g. ...The typical biphasic insulin secretion pattern observed with a square wave glucose stimulation

Photonics:
POF based glucose sensor incorporating grating wavelength filters

Civil Engineering:
Outdoor and indoor exposure to fine and ultrafine particulate matter...

"Statistically significant associations were found between indoor PNC, dominated by indoor use of candles, and lower lung function, the prediabetic marker HbA1c and..."
Overall Knowledge Landscape: “Climate Change”

DTU MAN

DTU MAN – QSA

DTU MAN – UNEP related

DTU Environment

DTU Space

DTU Chemical Engineering

DTU Aqua
Network and Formal Organisational Functions
Current Project: Advanced Mapping of Industrial Capabilities for Climate (AMICa)

Support the design and development of next generation biofuels as sustainable production systems

Faster  Cheaper  More Sustainable
BIOFUELS...

5,000 + patents
46,000 + scientific publications
1,000 + projects in EU CORDIS
Thousands of organisations

We need to actively expand the solution space!
Geographical distribution (country level) of biofuel-related knowledge assets by type

Map based on Longitude (generated) and Latitude (generated). Color shows details about Type. Details are shown for Country REC. The data is filtered on Owner Org REC (group), which keeps no members.

Geographical distribution (city level within northern Europe) of biofuel-related knowledge assets by type

Map based on Longitude (generated) and Latitude (generated). Color shows details about Type. Details are shown for Country Rec and City. The data is filtered on Owner Org Rec (group), which keeps no members.

DTU’s Knowledge Landscape – Biofuels
Underlying Infrastructure
Data Science Skills in a Research Workflow

Data Acquisition and Management
- Big Data Infrastructure and Tools
  - Harvesting
  - Storage
  - Maintenance

Data Analysis
- Data Science Analytics
  - Statistical Analysis
  - Machine Learning
  - Data, Text and Process Mining

Interpretation
- Domain Knowledge and Expertise
  - Interpretation and Visualisation

Source: Adapted from EDISON Data Science Framework
Data Infrastructure - Example

Data Infrastructure:
- **Data Inputs**
- **Data Pre-processing**
- **Graph Database** (e.g., Neo4j)
- **Analytics Workflow**
- **Analytics Libraries**
- **Visualization**
- **Cloud Server**
- **Project Documentation**
- **AMICa Website**

Visualization Tools:
- Tableau
- RawGraphs
- Apache Zeppelin
- Net-Sights
- RapidMiner
- R

Documentation and Repositories:
- GitHub

"GRAPH DATABASE"
"GRAPHENEDB"
"DATA INPUTS"
"ANALYTICS WORKFLOW"
"ANALYTICS LIBRARIES"
"VISUALISATION"
"CLOUD SERVER"
"PROJECT DOCUMENTATION"
"AMICa WEBSITE"
Data Sources and Models - Example

Open data sources

Connected data model
Final reflections
Important Lessons

1) Effective decision making support? → Only when it supports what you already believe on

We can and should do more about this
Important Lessons

2) Always remember:

• Modularity
• Interoperability/interfaces
• Open architectures and systems
• Scalability + rapid prototyping/agile development

Otherwise, the project can be unpredictably expensive!
Important Lessons

3) Quantity has a quality all its own

Macro connections are robust to random errors
Important Lessons

4) What we are capable > What we know is possible > What we do

We need to learn from other disciplines to advance faster
Summary

DATA-DRIVEN
We believe in a bottom-up approach driven by large amounts of data to generate new insights

FROM COUNTING TO CONNECTING
Our goal is to reveal the hidden connections and opportunities between otherwise disconnected possibilities

FROM ORGANISATIONS TO ECOSYSTEMS
Recombinant innovation requires to shift the focus from individual organisations to industrial ecosystems
Thanks!

More at [www.parraguezr.net](http://www.parraguezr.net)

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DTU Management Engineering
Engineering Systems Division
[www.es.man.dtu.dk](http://www.es.man.dtu.dk)