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## HOW TO TRAIN ARTIFICIAL INTELLIGENCE TO IMPROVE INDUSTRIAL APPLICABILITY OF LIFE CYCLE ASSESSMENT

\*Andreas Thore, \*\*Raul Carlsson

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RISE Research Institutes of Sweden

\*Applied digitalization, Digital systems

\*\*Certification development, Built environment

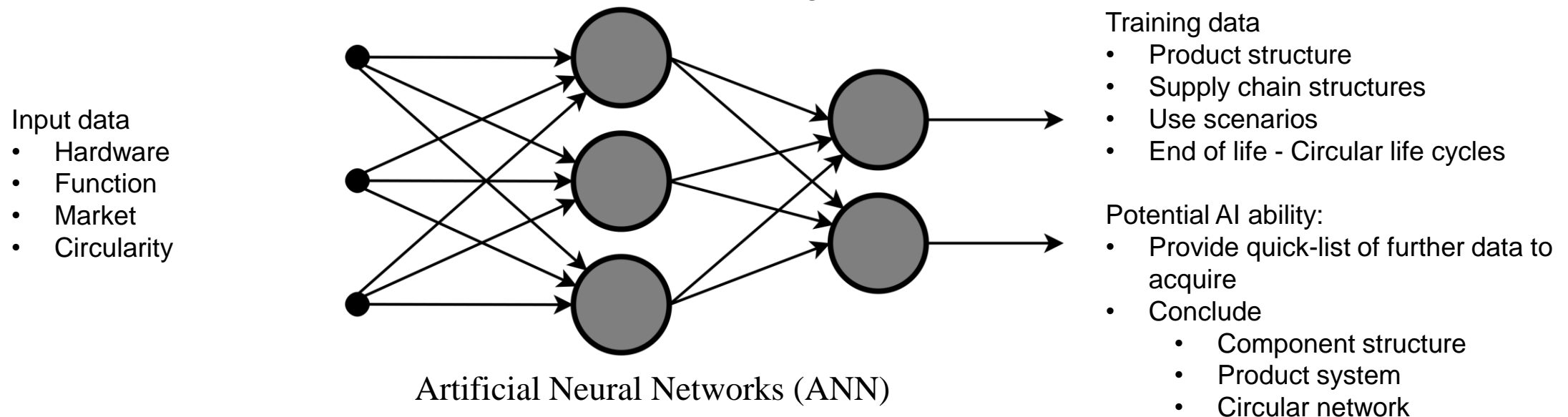
# Justification to introduce AI into LCA

- LCA requires intense amounts of intellectual resources that makes LCA costly and time consuming, yet still invaluable for decision making for sustainable transformation.
- Therefore it would be nice if Artificial intelligence (AI) could become a practical tool to enhance the LCA community's ability to meet society's demand for more, faster and better life cycle assessment (LCA) and footprint studies.

# Can we do this, then how?

- The paper discusses which strategy to apply to train artificial neural networks (ANN) so that the AI can get LCA right.
- A simple assumption about how an LCA AI may be used is that the AI is presented with a complex component and that it replies with the component's life cycle profile or by proposing an environmentally better alternative.

interpretation of input data into "intelligible" output data

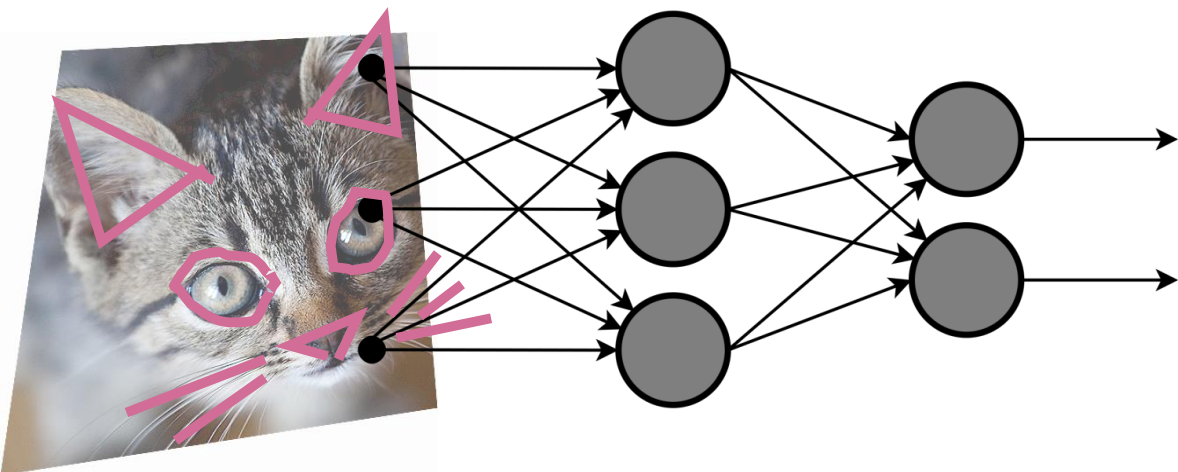


- How should an ANN be trained to achieve this, and which data would it then need to present such results?

# What is there for an AI to understand?

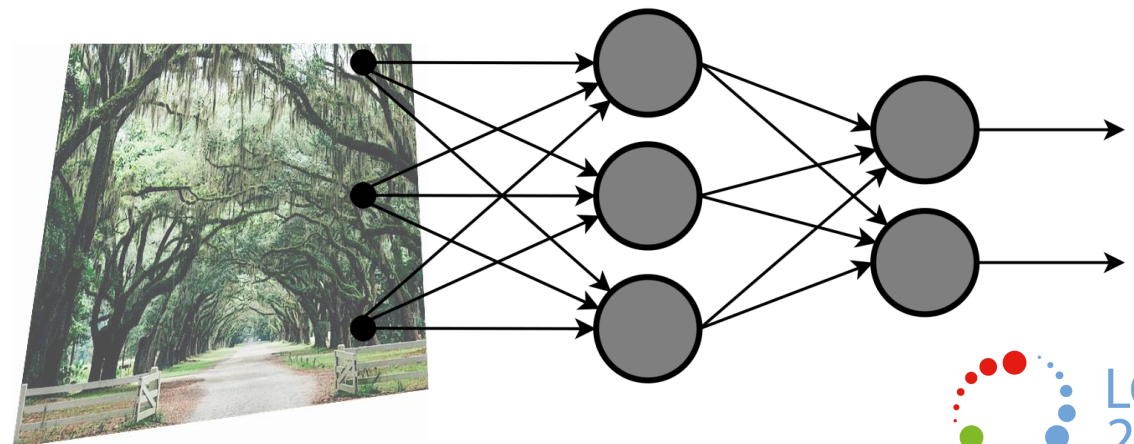
- In general an ANN is trained by providing it with some different and inexact data, and the ANN will learn to recognize not the data itself but some of its general patterns, so that it learns to put any new such data in a correct predefined category.

interpretation of input data into "intelligible" output data



Cat

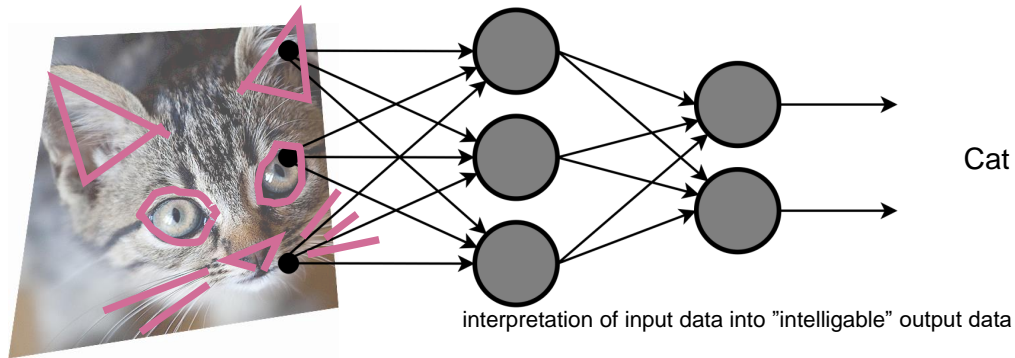
interpretation of input data into "intelligible" output data



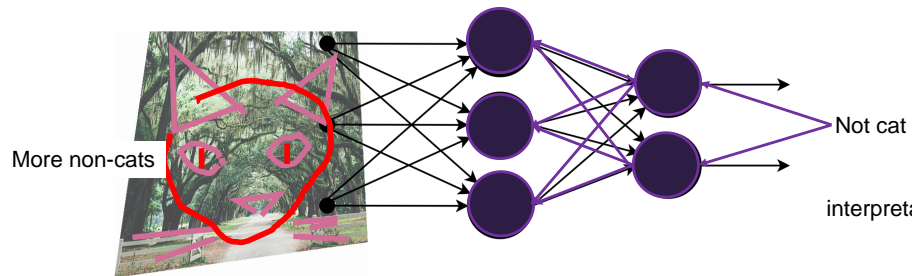
Cat

# Train and train again

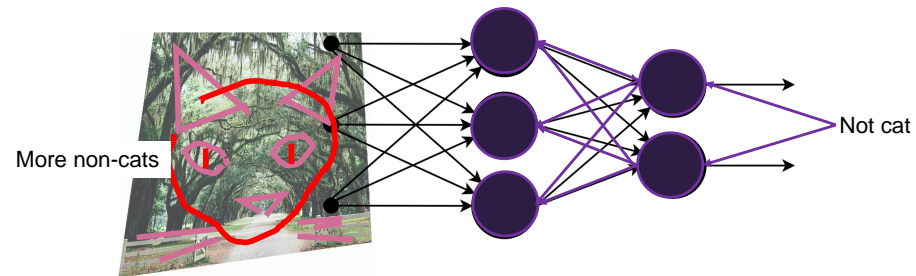
interpretation of input data into "intelligible" output data



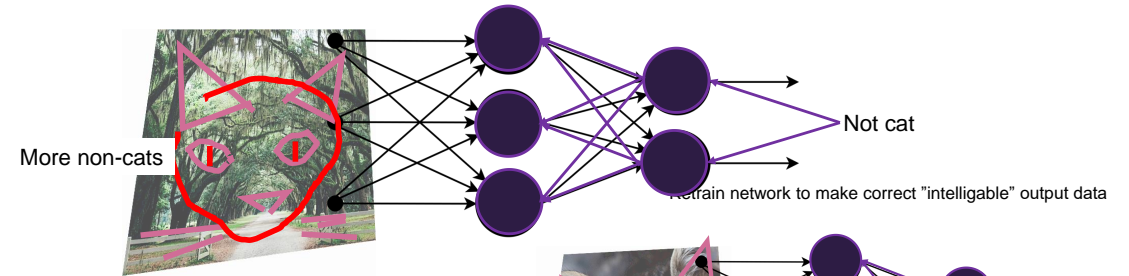
interpretation of input data into "intelligible" output data



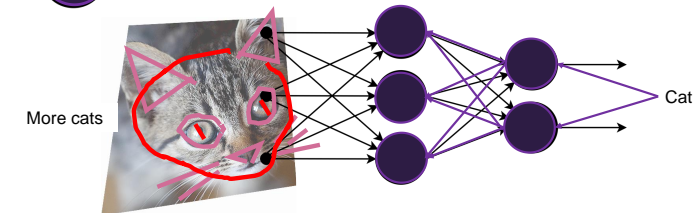
interpretation of input data into "intelligible" output data



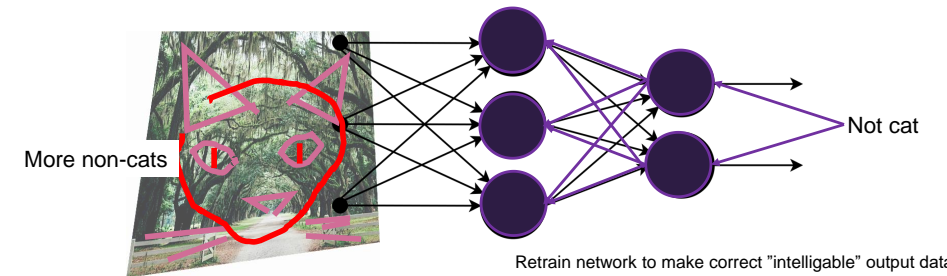
interpretation of input data into "intelligible" output data



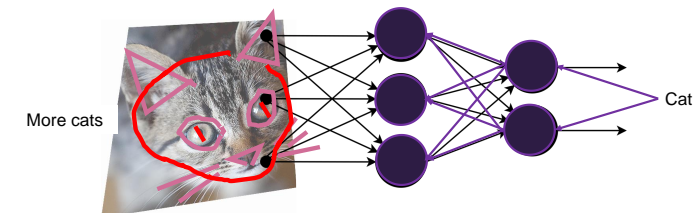
Retrain network to make correct "intelligible" output data



interpretation of input data into "intelligible" output data

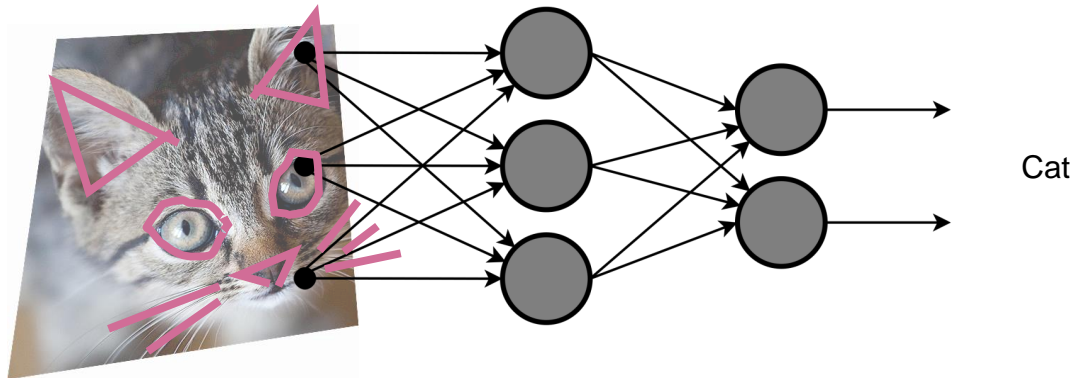


Retrain network to make correct "intelligible" output data

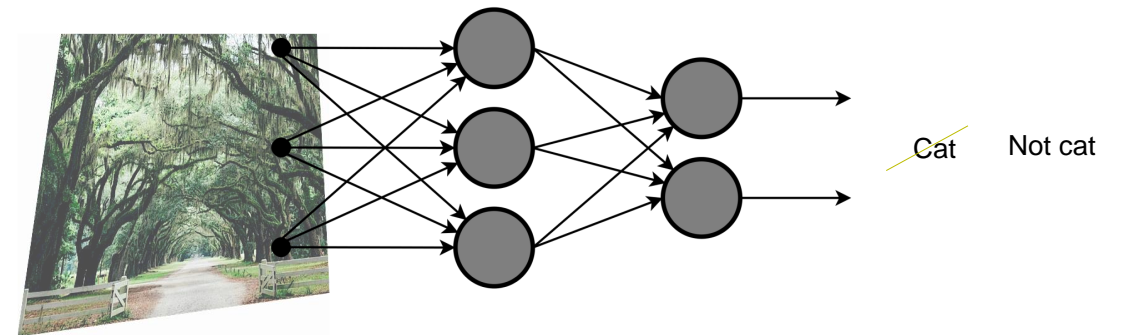


# If well trained, with cats and non-cats an AI can get it right

interpretation of input data into "intelligible" output data



interpretation of input data into "intelligible" output data



# What is there for an AI to get right about LCA?

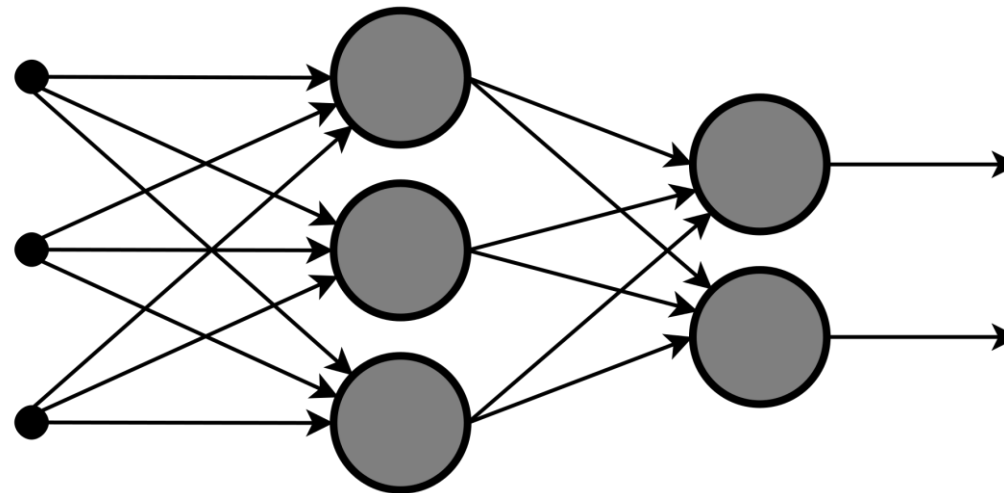
- To make use of AI to produce LCA:s we therefore need to know which inexact data and which correct categories to use to train an LCA AI ANN (Life cycle assessment Artificial Intelligence Artificial Neural Network).

interpretation of input data into "intelligible" output data

Input data

If presented with physical products....

Maybe, ....



Output data

....would it be possible to conclude an LCA result?

....in the same sense that an LCA database can provide ready-made study results.

But what would be the sense of using AI to find ready-made data in a database? We have done that since the 1990's.

For AI to be of any use, we would like it to help with something more useful, such as...

# What is there for an AI to get right about LCA?

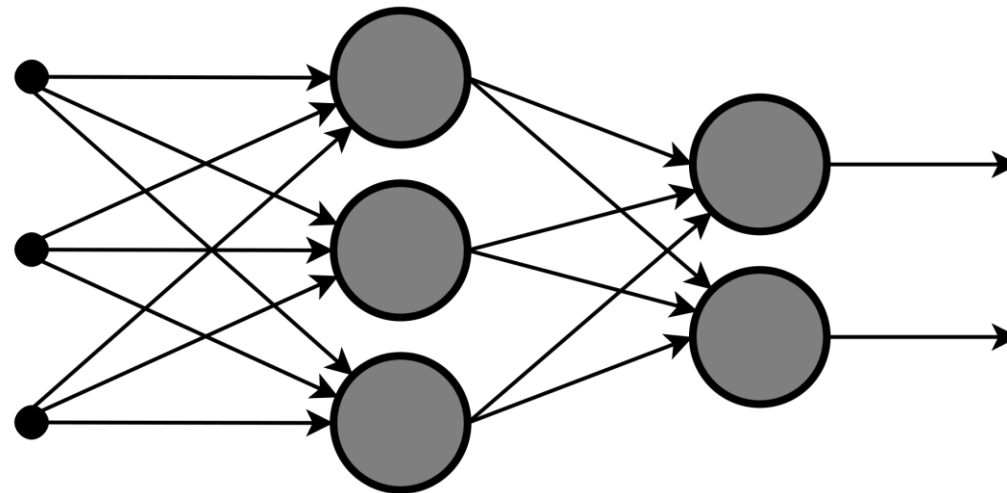
- To make use of AI to produce LCA:s we therefore need to know which inexact data and which correct categories to use to train an LCA AI.

interpretation of input data into "intelligible" output data

Input data

If presented with physical products....

And if given some additional data, ....



Output data

....would it be possible to conclude its component structure and material content?

....would it be possible to identify a real supply chain?

If that was possible, it might help a lot with drawing the flow chart.



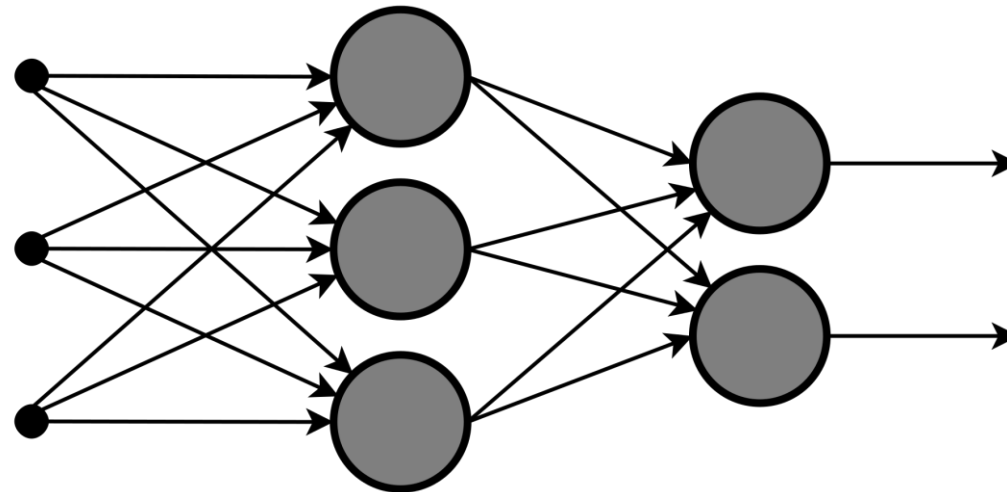
# What is there for an AI to get right about LCA?

- To make use of AI to produce LCA:s we therefore need to know which inexact data and which correct categories to use to train an LCA AI.

interpretation of input data into "intelligible" output data

Input data

...and, maybe, if the supply chain suggested by the AI could be further specified with some geographical data that a human looks up...



Output data

.... the AI might even help with appropriate choice of the most relevant unit process data.

If that was possible, it might help a lot with finding and modelling the entire life cycle inventory.

# How to find data to train the ANN into making the correct categorization, as well as which data would an AI need to calculate LCA results.

So, what type of training data would be required to teach an ANN to:

- to conclude the component structure and material content of a product?
- to identify a real supply chain?
- the appropriate choice of the most relevant unit process data?

# To teach an ANN to conclude the component structure and material content of a product

- As all the simple questions, this is hard enough on a very general level, but
  - If the ANN is allowed to have a limited range of products (such as electronics, furniture, automobiles, etc.)
  - and if the product is presented with sufficiently enough detailed data (brand name, time period of production, etc.)
  - Pretty good component structures and material lists may be suggested down to very high detail
- It might be much closer than we think, since
  - If a specific company or a specific sector decides to start building up this information together, it may be easy and fast to get such training data
  - If different companies and sectors work together, such component structures and material lists will soon be universal and global.

# To teach an ANN to identify a real supply chain

- At a very general level supply chains may be looked up as in today's LCI databases
- At very specific levels, such as when a company want to know exactly where their components and raw materials are sourced and manufactured, whenever any changes are made upstream, further data are needed, such as:
  - Continually request suppliers to report any changes in their supply chain
  - Continually request spot market statistics
  - etc.
- Note regarding specific levels data:
  - It is in principle very easy to follow an entire supply chain to the original source,
  - But due to business secrecy and other security aspects, such data are often protected.
  - Hence, one may need to establish new types of agreements throughout supply chains to get these data.

# To teach an ANN to conclude the appropriate choice of the most relevant unit process data

- At a very general level an appropriate choice of unit process data may be looked up as in today's LCI databases (not very interesting for AI)
- At very specific levels, such as when a company want to know if any changes in the supply chain has implications on sustainability impacts, such as climate impact, social impacts and the like, further data is needed, such as:
  - Continually request suppliers to report any changes in their supply chain
  - Continually request spot market statistics
  - etc.
- Note regarding specific unit processes:
  - It is still hard to get relevant specific sustainability data from many organizations,
  - However, estimations may be done from combining information about, e.g.
  - Geographical location, technology level, existence of management certificates, legislation etc.

# In conclusion

- LCA may very well be supported by using AI, but there are challenges to find verifiable data to train the ANN to know what leads to a correct LCA:
  - AI should help with specific time-consuming tasks, where exact data can be available, such as
    - Component structures and supply chains
  - And AI may be of help to reasonably estimate e.g.
    - Sustainability loads or impacts, based on contextual data
- Other similar types of support may be to
  - Identify potential hot-spots
  - Suggest alternative supply chains
  - And other data intensive types of ‘intelligence’
- However AI is introduced to support LCA
  - An ANN trained on biased data might amplify the bias, this is particularly important to consider if using AI to speed up uses of existing databases
  - To train an ANN to avoid bias, one need to find good raw data channels to tap in on, such as the upcoming EU digital product passport (DPP), different internet of things solutions, as well as different material traceability schemes currently being established.



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## CONTACTS

Raul Carlsson

[raul.carlsson@ri.se](mailto:raul.carlsson@ri.se)

0706151254

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