



Embedding Domain Knowledge in DNN

AI Shot #2 @ VISUM

Kelwin Fernandes, Ph.D.
CEO at nilg.ai
kelwin@nilg.ai



01

The Learning Spectrum

AI shot

02

Embedding Domain Knowledge

AI shot

03

AI use case

04

Self-Supervised Learning

AI shot

01

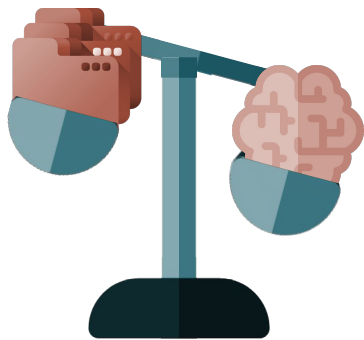
The good
old days



The good old days

Before and After Deep Learning

Before Deep Learning

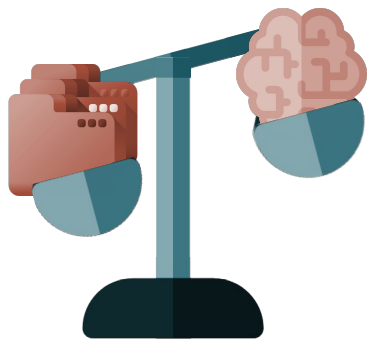


- Tons of focus on **feature engineering** and **domain understanding**.
- Manual-intensive task.
- Do you need a COVID-19 detection model?
 - Sure! give me 10 Ph.D., a budget for 5 years, **1K images**.
 - Then, I'll come close to a PoC that can only be used under these strictly designed settings.

The good old days

Before and After Deep Learning

After Deep Learning



- The new popular kid arrived to the school.
- Getting models for new applications “for-free”.
- Do you need a COVID-19 detection model?
 - Sure! give me 1 month, a monkey capable of pressing two buttons (fit+predict) and **1M images**.
 - Then, I'll have a model that seems to be working better than humans... at least on silico.

The good old days

Before and After Deep Learning

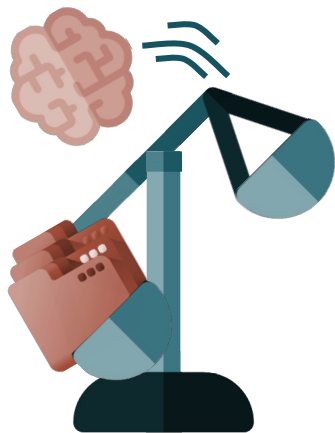


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- So, people got mad...

The good old days

Before and After Deep Learning



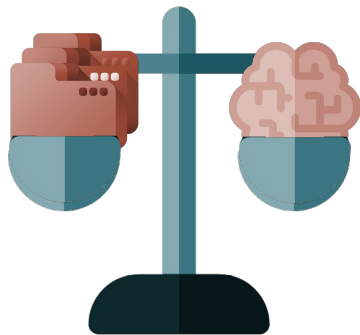
After Deep Learning

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 - Then, I'll have a model that seems to be working better than humans... at least on silico.
- So, people got mad... up to the point where we almost discard human experience as a valid source of knowledge.

The good old days

Before and After Deep Learning

Embedding Domain Knowledge in DNN



- Not so bald nor with two wigs
 - (a bit of venezuelan wisdom)
- We can have a mid-point where:
 - We understand the business.
 - We understand the tech.
 - We know how to elevate the tech to the business.
 - Instead of dumbing down the business to fit the tech.

02

Embedding Domain Knowledge in DNN

(examples from real industry projects)



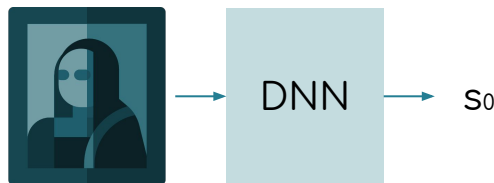
We will discuss multiple
examples and how to build
tailored DNN for each case...

Fasten your seatbelts.
Please try this at home!

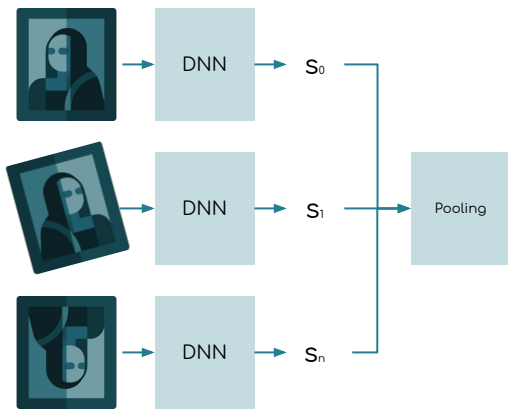


Adding Invariances: The easy way

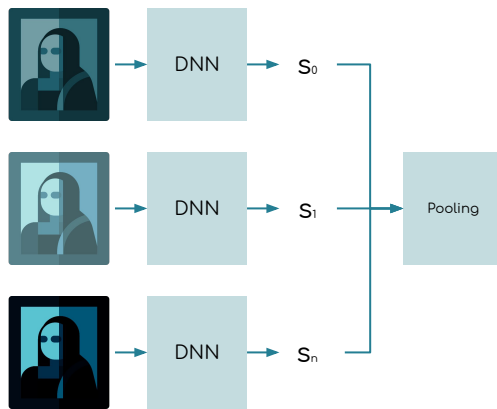
Synthetic (or natural) Data
Augmentation at Inference



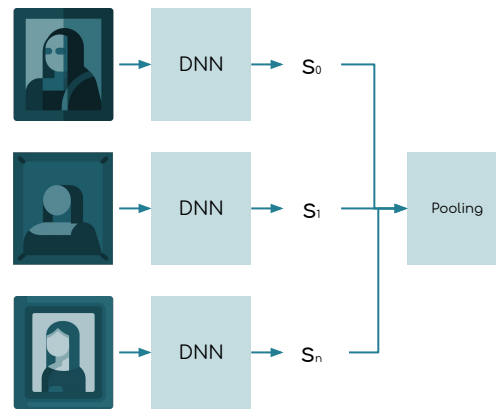
Flips/Rotations



Illumination/Contrast



Multiple Views/Poses



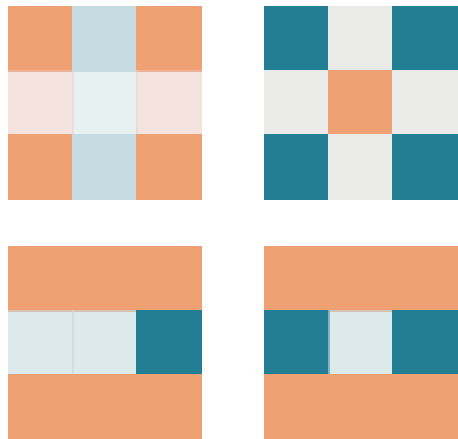
Adding Invariances: The hard way

Local Preprocessing or...

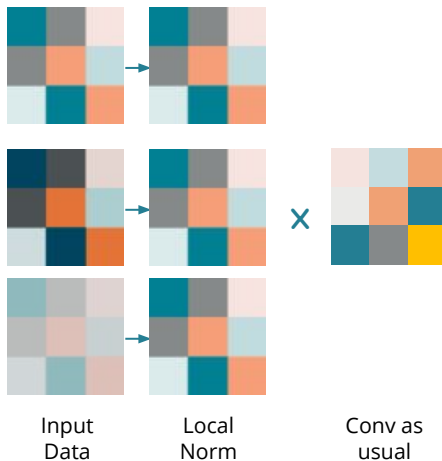
Building tailored convolutional
kernels/architectures



Flips/Rotations



Illumination/Contrast



Multiple Views/Poses

Ask Geoffrey Hinton
about
capsule neural
networks

Adding Invariances

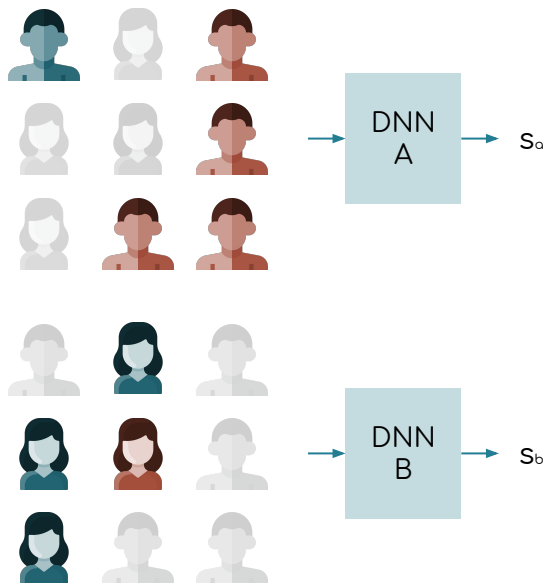
Group invariance:

race, gender, country, deep-learning-framework-preference

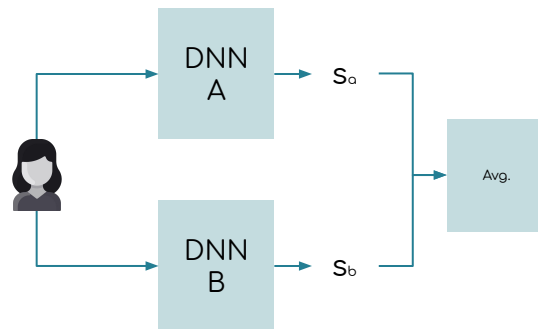
Biased Dataset



Train a model per group

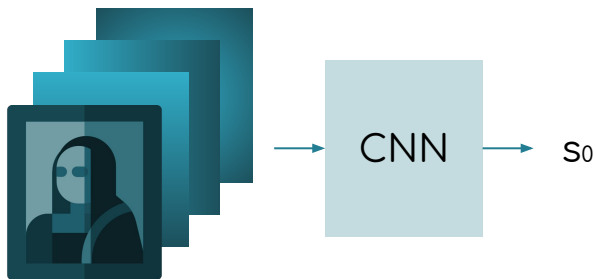
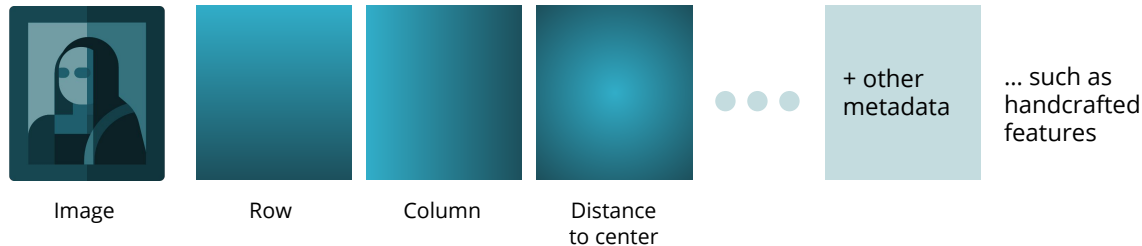


Avg. voting as prediction



Removing Invariances

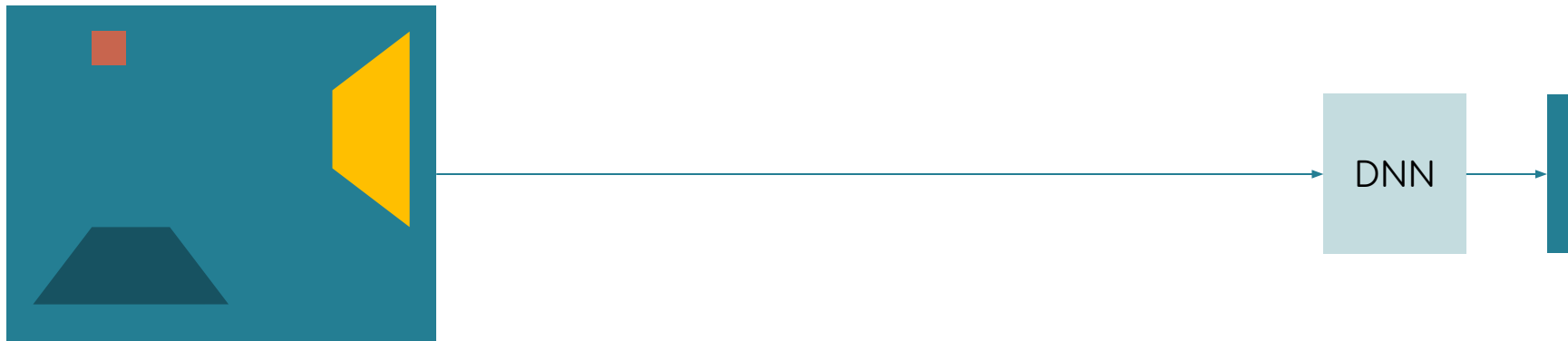
- Remove translational invariance from convolutional kernels
 - Add pixel location as additional channels



Note: you can have two sets of kernels, one with and one without spatial coordinates so you get the best from the two worlds.

Industrial process monitoring

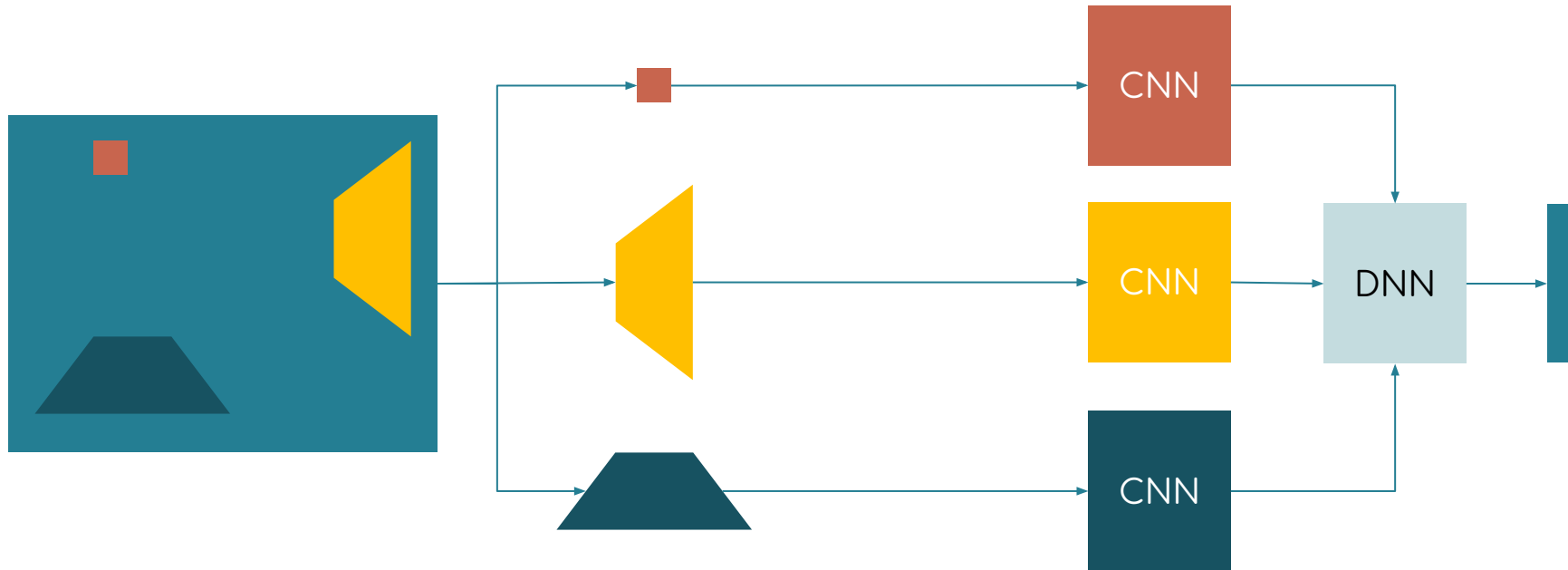
Validate a production chain that involves a known set of steps/signals



You had to re-train the model for new layouts and perspective conditions!!!

Industrial process monitoring

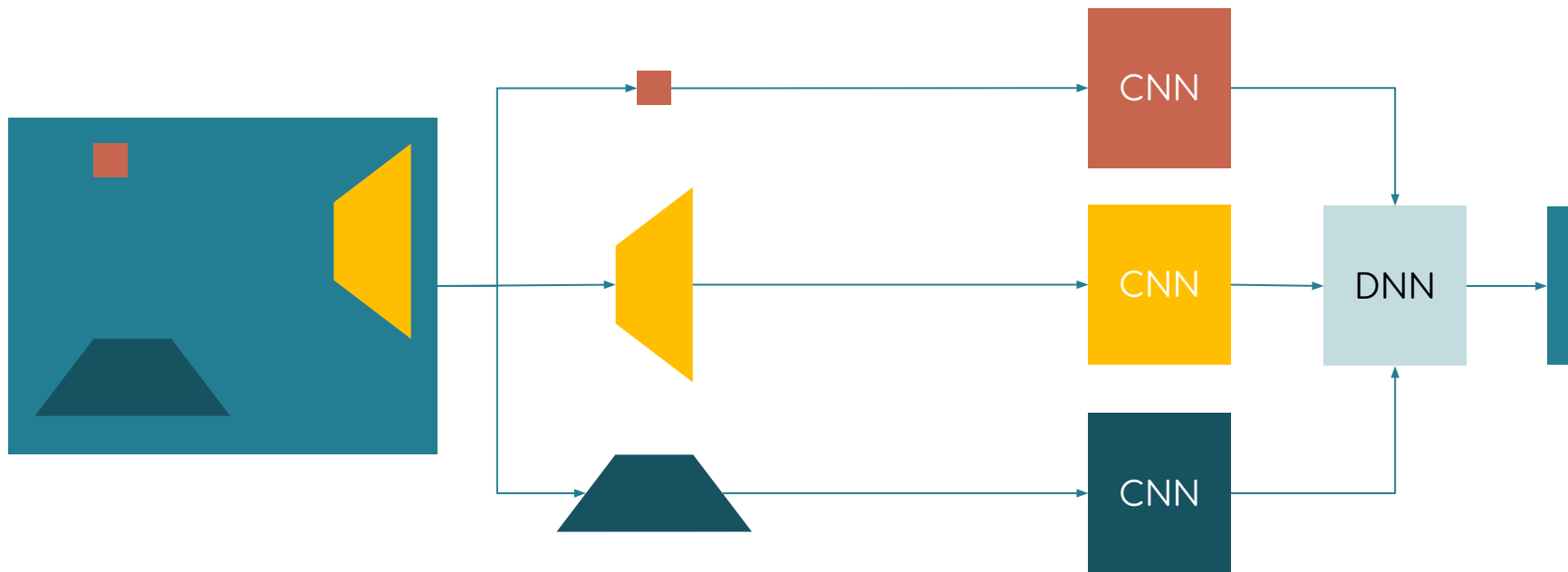
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Industrial process monitoring

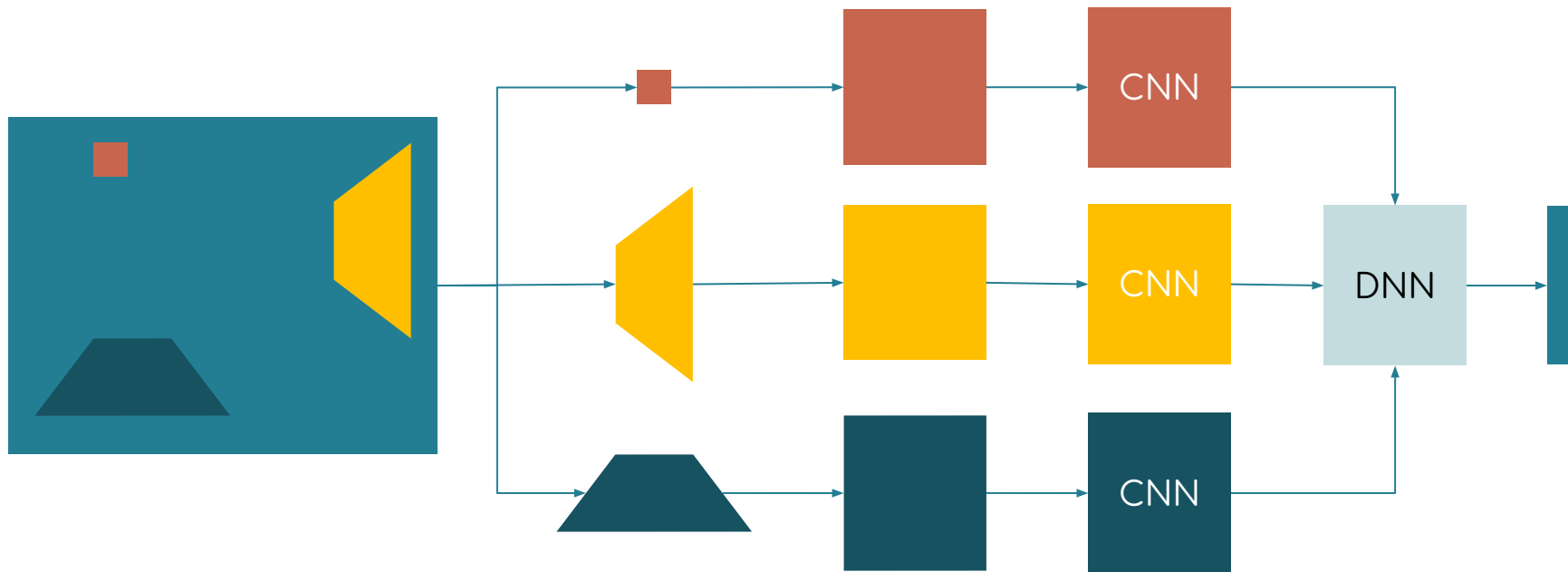
Validate a production chain that involves a known set of steps/signals



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Industrial process monitoring

Validate a production chain that involves a known set of steps/signals



Now you have a model that is robust to layout and perspective changes and it's new! Welcome!

Forecasting stock per SKU

Predict how many units I'll sell next week from each product type

First attempt:
naive regression



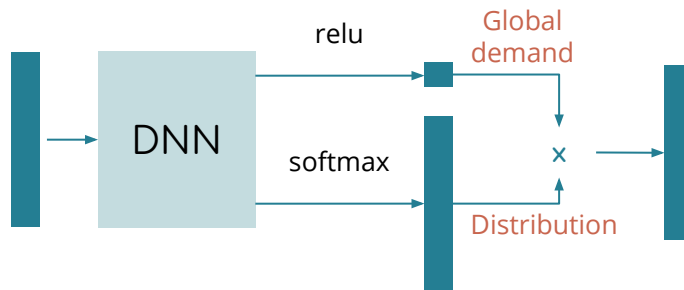
Second attempt:
regression knowing you cannot have negative demand



Third attempt:

Easen the task by
learning 2 simpler tasks:

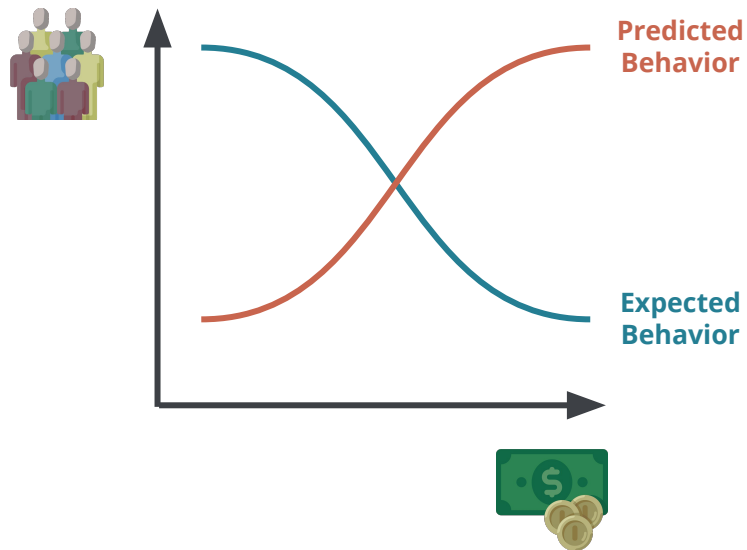
- Global Demand
- Distribution



Demand forecast given price

Highly seasonal industry (e.g., travel, fashion)

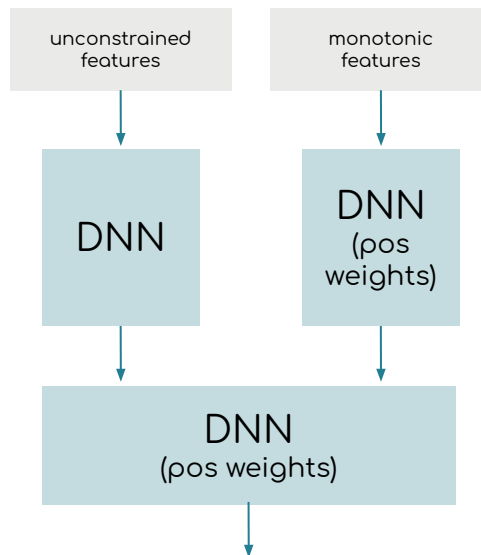
Given flight, time and price, and recent context, what's the expected demand?



Demand forecast given price

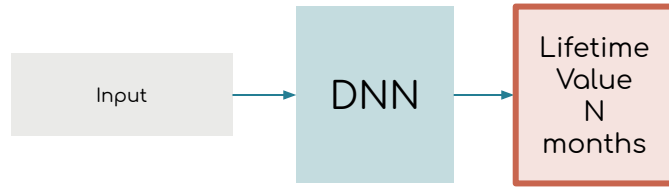
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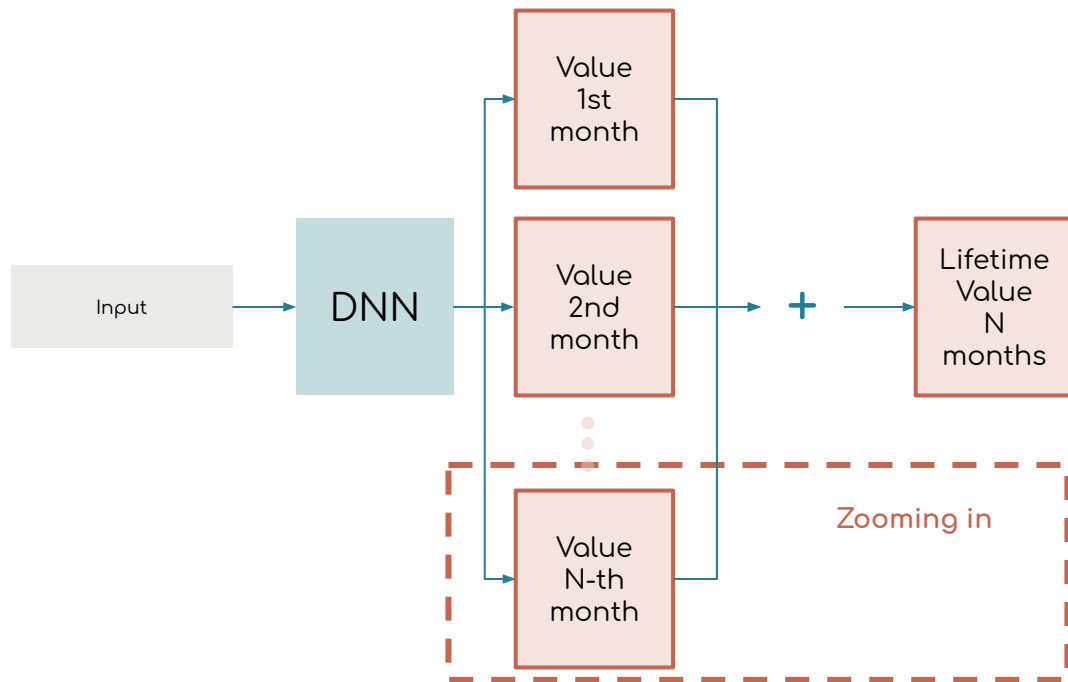
Customer Lifetime Value

When harder is simpler



Customer Lifetime Value

When harder is simpler



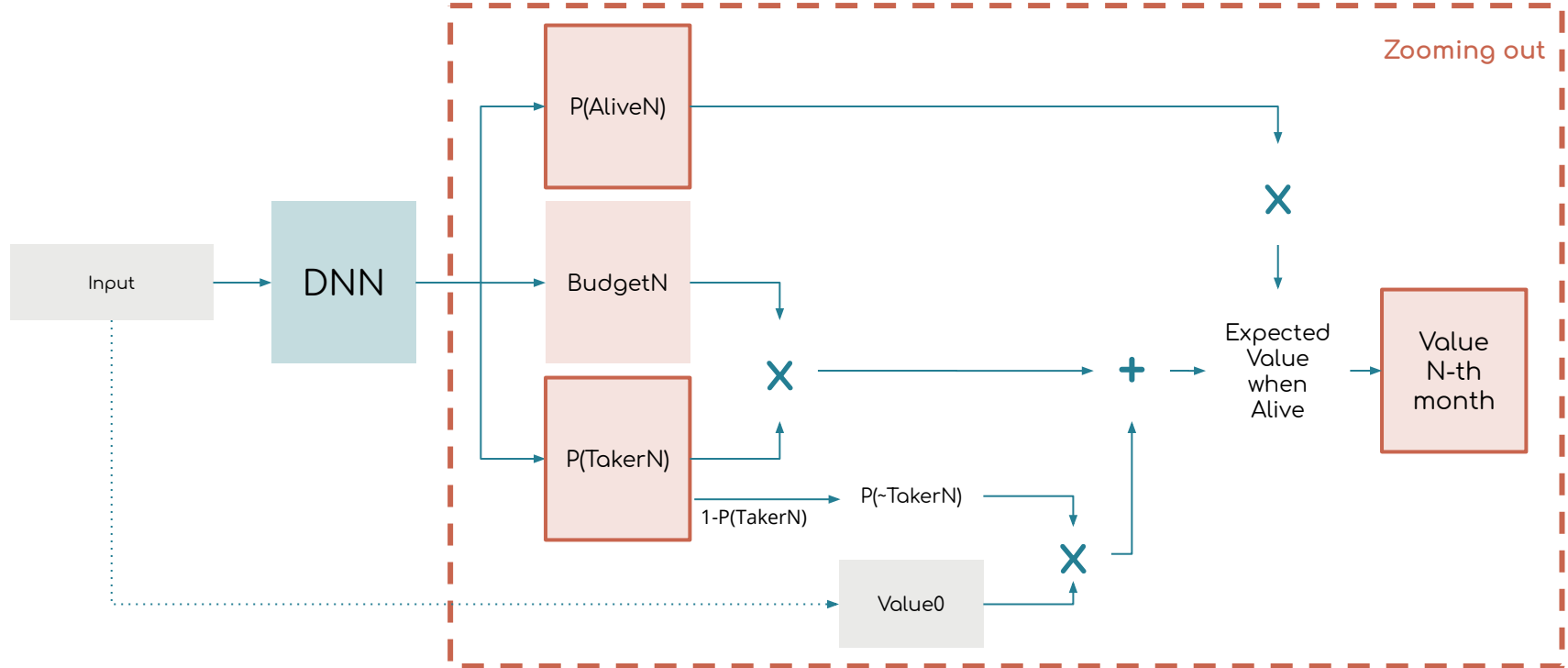
$$\text{Expected Value} = \text{Prob}(\text{Alive}) * \text{TotalBudget} + (1 - \text{Prob}(\text{Alive})) * 0$$

$$\text{TotalBudget} = \text{Prob}(\text{Taker}) * \text{Budget} + (1 - \text{Prob}(\text{Taker})) * \text{InitialValue}$$

$$\text{Expected Value} = \text{Prob}(\text{Alive}) * (\text{Prob}(\text{Taker}) * \text{Budget} + (1 - \text{Prob}(\text{Taker})) * \text{InitialValue})$$

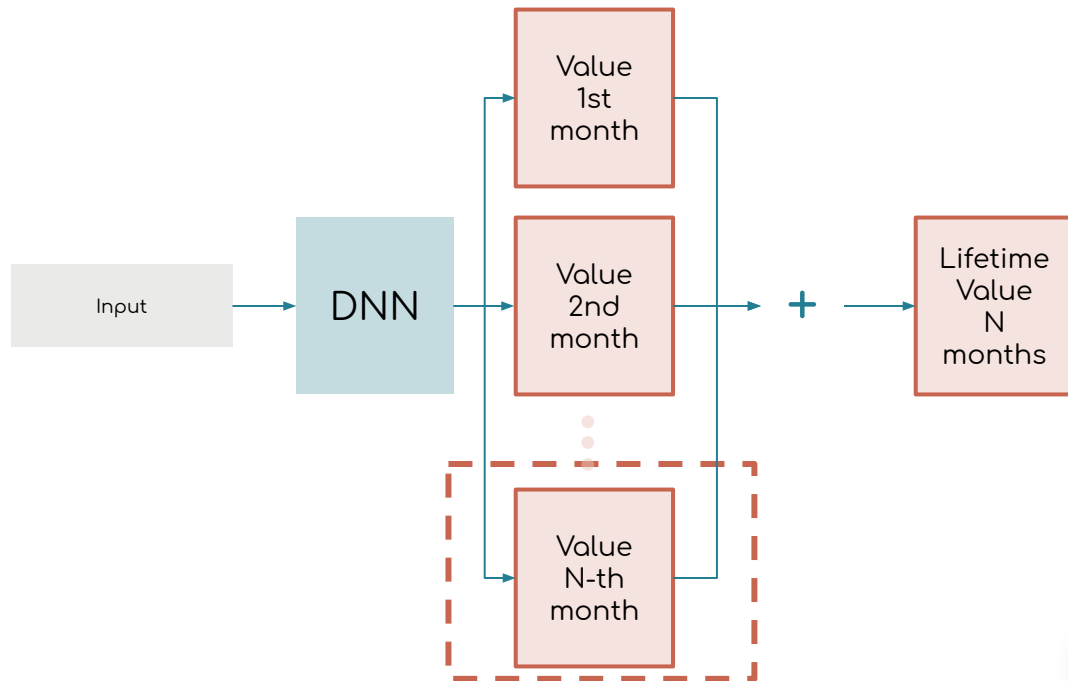
Customer Lifetime Value

When harder is simpler



Customer Lifetime Value

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Why adding complexity and investing that much effort?

- Additional tasks act as regularizers.
- Giving additional supervision of the internal business processes:
 - Facilitates the discovery of features relevant for those tasks.
 - Avoids catastrophic failures due to unmatching business-machine rules.
- We reduced the MAE by 50% ;-)



<https://nilg.ai/blog/202004/embedding-domain-knowledge-for-estimating-customer-lifetime-value/>

Conclusion



- Deep Neural Networks are not the black-box monster they told you.
- They can actually be a good dog if you know how to train (or breed) them!
- Domain knowledge isn't (always) bad.
 - It can help you to learn with **less data**.
 - It can help you avoid **catastrophic failure**.
 - So you can rest tonight! Assured that your Project Manager won't call you at midnight because your model decided to sell cars at \$0 to maximize buying probability.

Thank you!
Questions?





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