

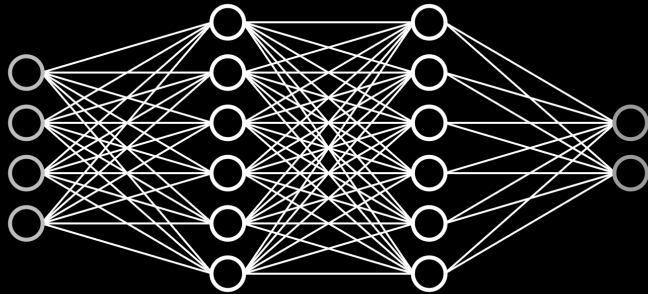
LEGO® Deep Learning



FACT, BNAIC/Benelearn 2021
Gilles Louppe, g.louppe@uliege.be

1960-2012:

The pre-deep learning era.



The age of discovery.

He was born curious. First he discovered his fingers and toes. Now he's exploring the world around him. It's this natural curiosity that gives birth to creativity and imagination.

And to keep that curiosity busy, there are LEGO® Brand PreSchool Building Sets. The big, colorful blocks snap together easily. The wheels roll, the friendly figures smile. Whether he's building a house or a who-knows-what, it's fun. It's enriching. Discover LEGO PreSchool. And help grow a great imagination!



LEGO PreSchool Sets
(See LEGO sets for all ages at your local store.)

1978 ©LEGO Systems, Inc., Enfield, Ct. 06082. LEGO® is a registered trademark of Interlego A.G.

"Look what I built with LEGO!"

And look at that look on her face. That's pride smiling!

The feeling of accomplishment children get from building with LEGO® Brand Building Sets is something no child should miss. And something no parent should miss sharing.

LEGO bricks and pieces are beautifully crafted. They snap together to build anything a child can imagine. Snap apart to start all over again.

There are wheels to make things go, doors and shutters to open and close, LEGO people to grin right back at your child.

LEGO is a toy they never tire of, a toy that stimulates creativity and imagination for years.

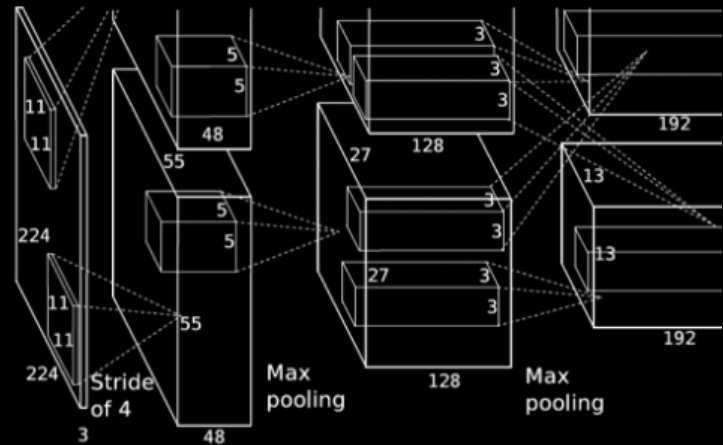
What more could you ask of a toy?

LEGO Building Sets
(See LEGO sets for all ages at your local store.)



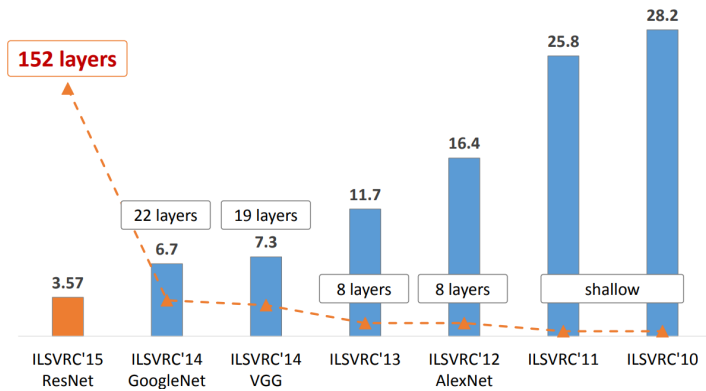
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2012: AlexNet



2012-Present:

The deep learning revolution.

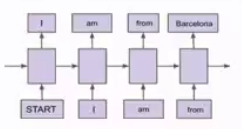


The deep learning toolbox

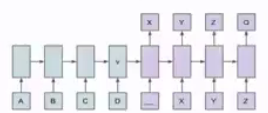
Feed forward models



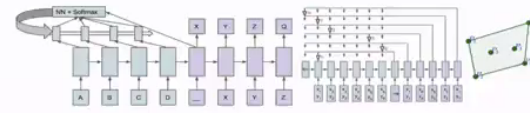
Sequence Prediction



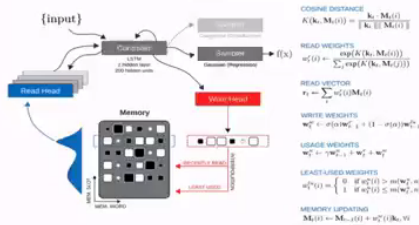
Seq2Seq



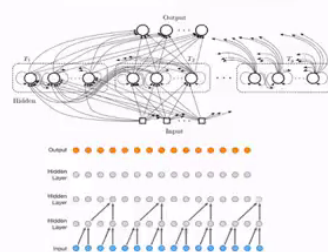
Attention & Pointers



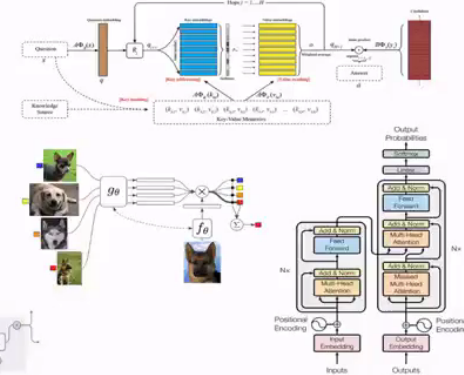
Read/Write memories



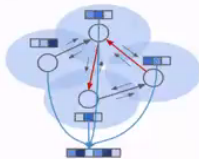
Temporal Hierarchies



Key, Value memories



Graph Neural Networks

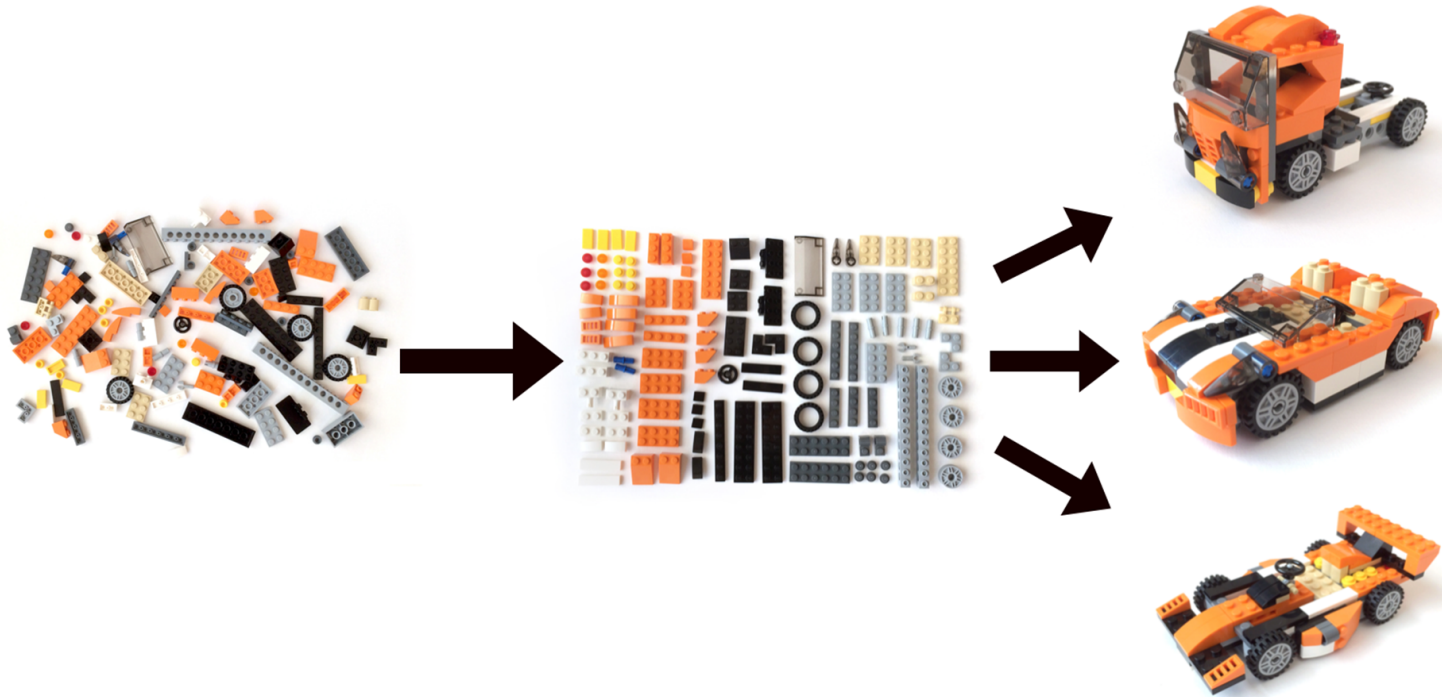


Recurrent Architectures



Figure credits: Jeff Dean, Chris Olah, Santoro et al 2016, Koutnik et al 2014, van den Oord et al 2016, Miller et al 2016, Vinyals et al 2016, Vaswani et al 2017

An architectural language





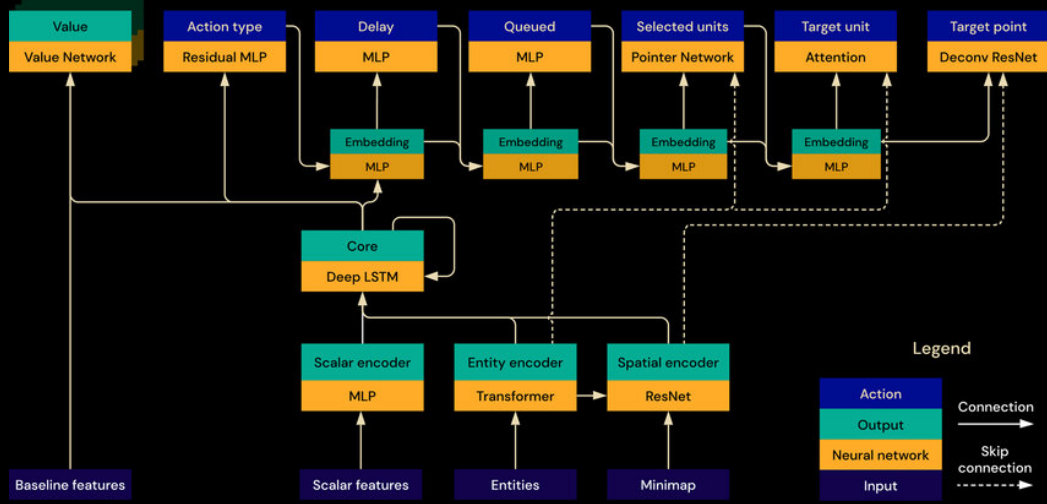
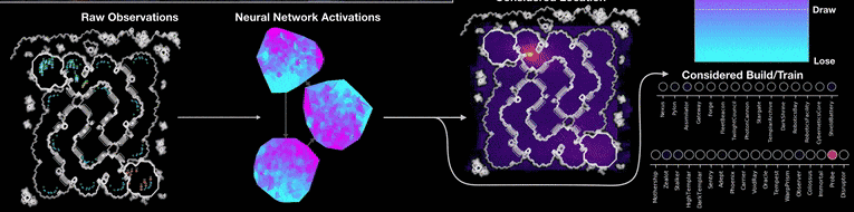
People are now building a new kind of software by **assembling networks of parameterized functional blocks** and by **training them from examples using some form of gradient-based optimization**.

An increasingly large number of people are defining the networks procedurally in a data-dependent way (with loops and conditionals), allowing them to change dynamically as a function of the input data fed to them.

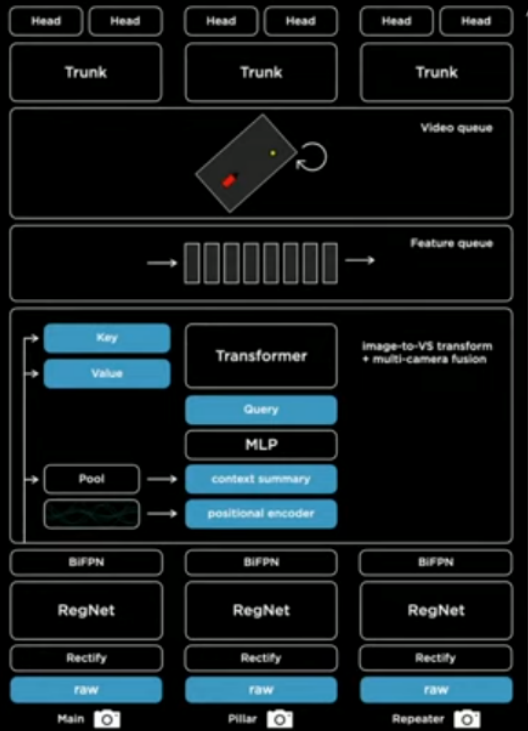
Yann LeCun, 2018.

LEGO® Creator Expert

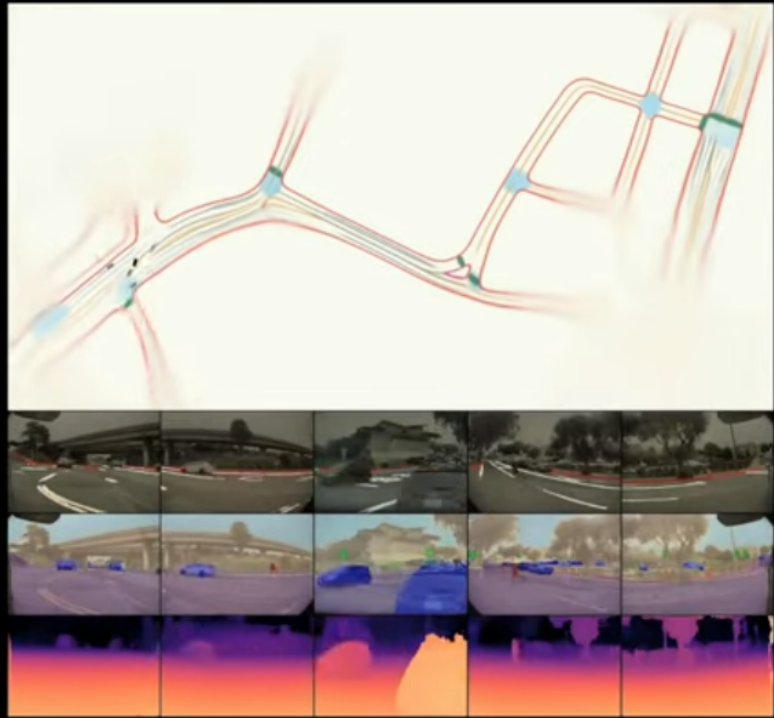
AlphaStar (Vinyals et al, 2019)



Hydranet (Tesla, 2021)

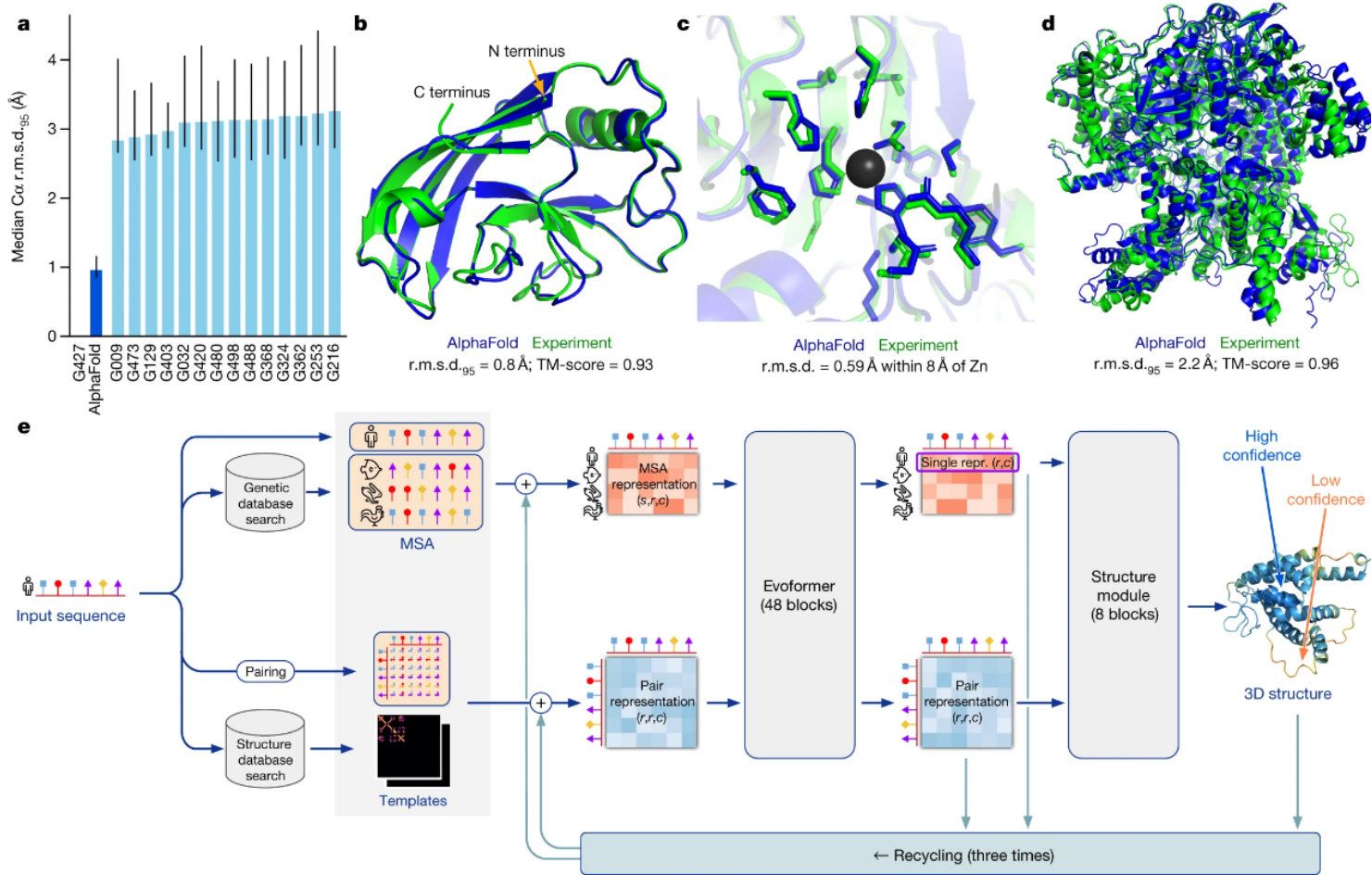


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TESLA LIVE

AlphaFold (Jumper et al, 2021)



Conclusions

- Deep Learning is more than feedforward networks.
- It is a **methodology**:
 - assemble networks of parameterized functional blocks
 - train them from examples using some form of gradient-based optimisation.
- Bricks are simple, but their nested composition can be arbitrarily complicated.
- Think like an architect: make cathedrals!

