Neural Architecture Search (NAS)

Week 12 – Advanced Topic 1

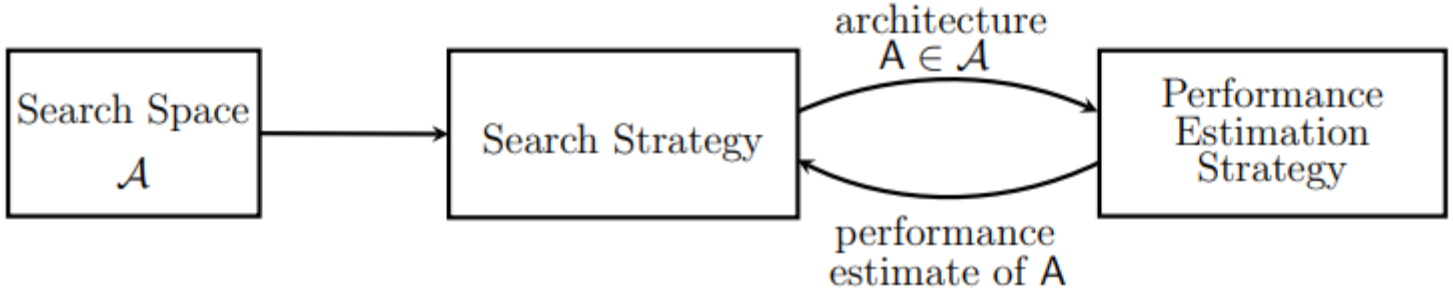
Ahmed Abdelgayed, Chinmay Patwardhan

Norwegian University of Science and Technology

Key points

- NAS problem definition.
- Key Concepts
- Main NAS Algorithms
- Areas of applications
- How to adopt NAS in your Model Development?
- Pros vs Cons

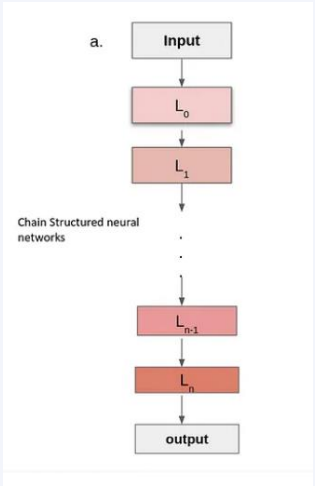
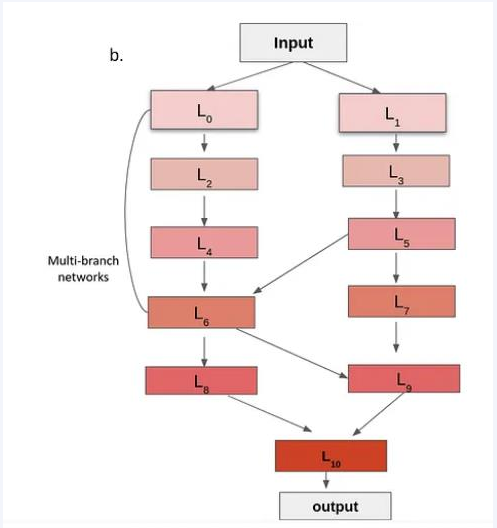
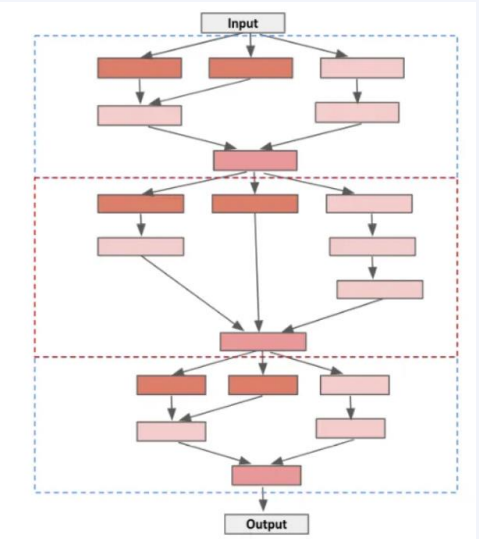
A method for automating Neural Network design



(Elsken et al., 2019)

Search Space

“The type(s) of artificial neural networks that can be designed and optmised for a task”

Macro Architectures		**Micro Architectures**
Chain Structured NNs	Multi-branched NNs	“Cell” Based – Objective is to find optimal cells instead of whole architectures
		Cells can be: **«Normal Cell»** Dimentionality of input is preserved **«Reduction Cell»** Dimensionality reduction 

https://medium.com/@deeptij2007/neural-architecture-search-nas-a-summary-c611d259ccb8

The Search Strategy: Optimization Techniques

Blackbox Optimization Techniques

- Random Search
- Reinforcement Learning NAS
- Genetic/Evolutionary NAS
- Bayesian Optimization
- Monte-Carlo Tree Search

One Shot Techniques

- Supernetwork Methods
- Hypernetwork Methods

The Search Strategy: Optimization Techniques

Blackbox Optimization Techniques

Pros:

- More robust than one-shot methods.
- Simpler optimization
- Easier adaptation to new datasets, problems or search spaces.
- Often conceptually simpler than one-shot methods.

Cons:

- When applied without speedup techniques, they have immense computational costs

One Shot Techniques

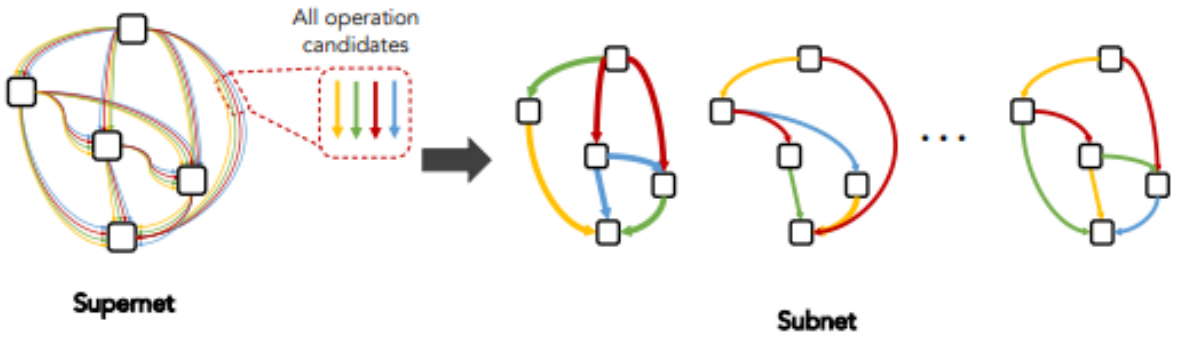
Pros:

- Avoids training each architecture from scratch, so has better computational efficiency
- Large search spaces

Cons:

- Approximation errors
- Implementation complexity

Applications (Graph NN)



Source: Neural Architecture Search: Insights from 1000 Papers

Graph Neural Networks:

- Graphs --> complex structure

Search spaces:

- Custom spaces with specialized operaitions (edge features and meta path)

Search strategies:

- Typical NAS search strategies (RL, Evolutionary, and one-shot methods)

Applications (Generative Adversarial Networks GAN)

GANs:

- Incorporates generator and discriminator

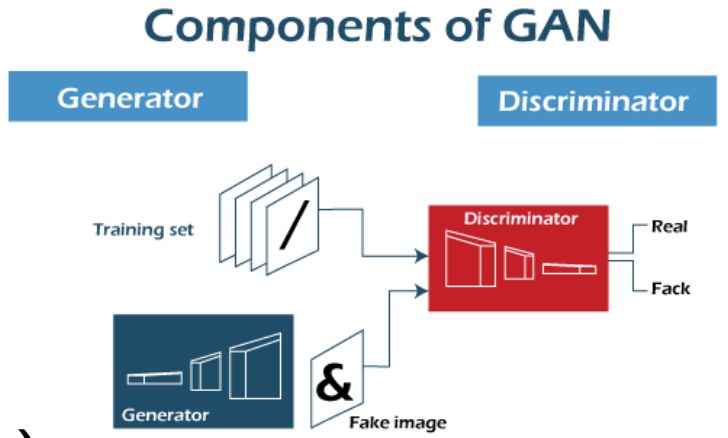


Figure source

Search spaces:

- Cell-based (conv-cell & Up/sampling operation)
- Searching only Generator / Generator and discriminator

Search strategies:

- Typical NAS search strategies (RL, Evolutionary, and one-shot methods).

How to Apply NAS in Your Model?

1. Define your search space (e.g. cell-based, custom features, .., etc)
2. Select a search strategy (RL, BO, EA)
3. Select Evaluation Metrics of your model performance (accuracy, loss, domain-specific, … , etc)
4. Perform the Search to select a candidate archeticture
5. Train and evaluate perfomance
6. Steps 4 and 5 are repeated depending on search strategy
7. Fune-tune your best candidate Architecture

Pros vs Cons

Pros

- Automates the design of highly performant architectures.
- Achieves competitive results without expert tuning.

Cons:

- Computationally expensive.
- Expertise in defining the search space for your problem

Summary

- NAS is essentially **a tool for finding optimal neural architectures** for a given problem.

- Three main components
  - **Search Space**
  - **Search Strategy**
  - **Performance Estimation**

References

- Colin White, Mahmoud Safari, Rhea Sukthanker, Binxin Ru, Thomas Elsken, Arber Zela, Debadeepta Dey, and Frank Hutter. "Neural Architecture Search: Insights from 1000 Papers." arXiv preprint arXiv:2301.08727 (2023).