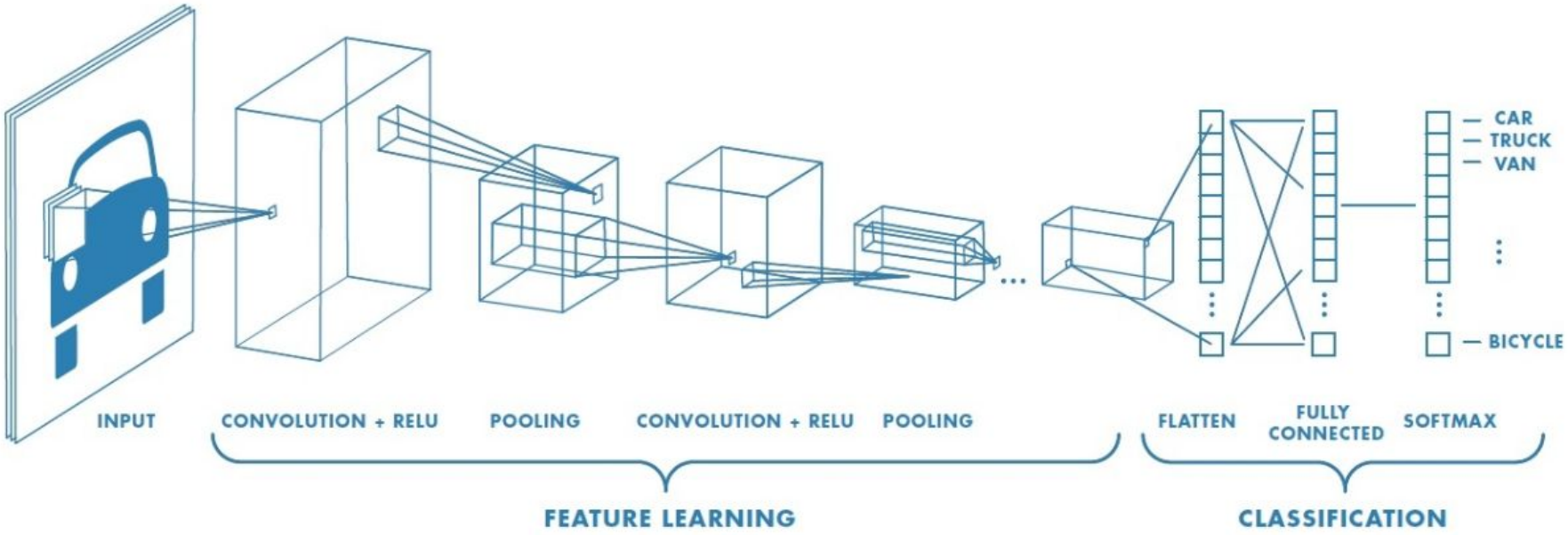
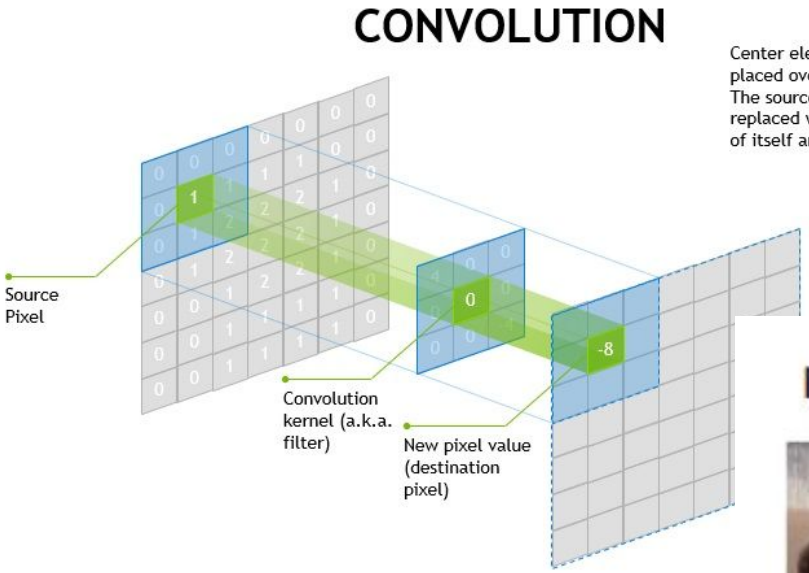
Constructing CNN with GA

Group 7

What is CNN? - overview



What is CNN? - convolution



Input image

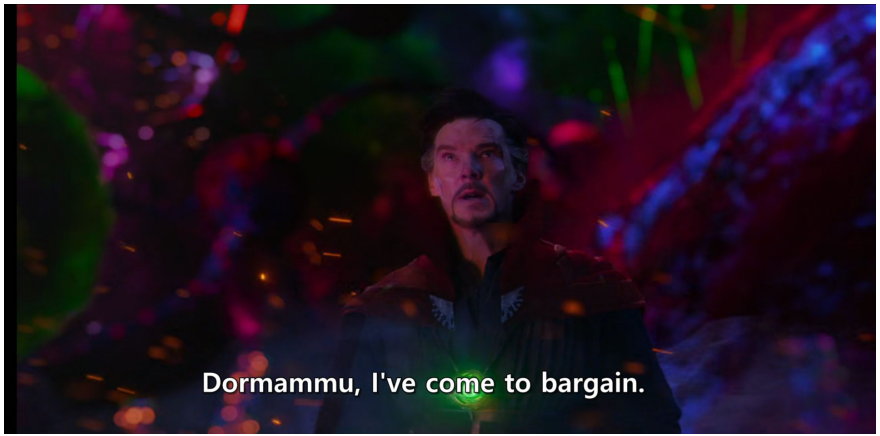
Convolution Kernel

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Feature map

Motivation - trial and error

- How did people design CNN?
  - Design each layers
  - Stack layers
  - Optimize hyperparameters
  - ...
  - *Try again!*



“TRIAL and ERROR”

Motivation - with GP

“Finding a best performing neural network model”

- Representation
  - Detail of layers
- Fitness
  - Test accuracy of the model
- Operator
  - How?

Recent Research

A Genetic Programming Approach to Designing Convolutional Neural Network Architectures*

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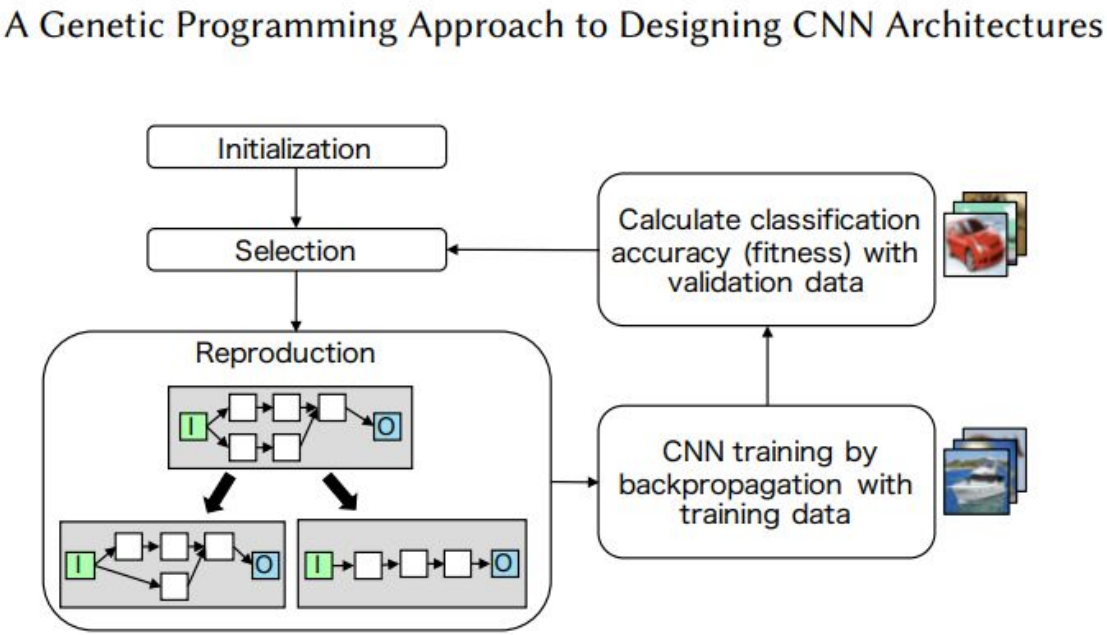
ABSTRACT

The convolutional neural network (CNN), which is one of the deep learning models, has seen much success in a variety of computer vision tasks. However, designing CNN architectures still requires expert knowledge and a lot of trial and error. In this paper, we attempt to automatically construct CNN architectures for an image classification task based on Cartesian genetic programming (CGP). In our method, we adopt highly functional modules, such as convolutional blocks and tensor concatenation, as the node functions in CGP. The CNN structure and connectivity represented by the CGP encoding method are optimized to maximize the validation accuracy. To evaluate the proposed method, we constructed a CNN architecture for the image classification task with the CIFAR-10 dataset. The experimental result shows that the proposed method can be used to automatically find the competitive CNN architecture compared with state-of-the-art models.

few years and are applied to various computer vision applications [39, 40]. A commonly used CNN architecture consists mostly of several convolutions, pooling, and fully connected layers. Several recent studies focus on developing a novel CNN architecture that achieves higher classification accuracy, e.g., GoogleNet [35], ResNet [10], and DensNet [12]. Despite their success, designing CNN architectures is still a difficult task because many design parameters exist, such as the depth of a network, the type and parameters of each layer, and the connectivity of the layers. State-of-the-art CNN architectures have become deep and complex, which suggests that a significant number of design parameters should be tuned to realize the best performance for a specific dataset. Therefore, trial-and-error or expert knowledge is required when users construct suitable architectures for their target datasets. In light of this situation, automatic design methods for CNN architectures are highly beneficial.

SUGANUMA, Masanori; SHIRAKAWA, Shinichi; NAGAO, Tomoharu. A genetic programming approach to designing convolutional neural network architectures. In: *Proceedings of the Genetic and Evolutionary Computation Conference*. ACM, 2017. p. 497-504.

Recent Research - genetic programming



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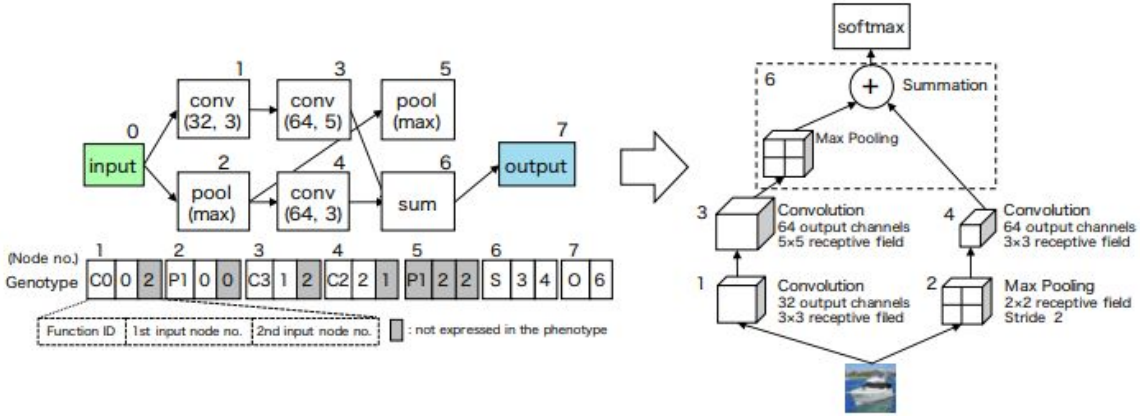
Recent Research - representation



Node type	Symbol	Variation
ConvBlock	CB (C', k)	$C' \in \{32, 64, 128\}$
		$k \in \{3 \times 3, 5 \times 5\}$
ResBlock	RB (C', k)	$C' \in \{32, 64, 128\}$
		$k \in \{3 \times 3, 5 \times 5\}$
Max pooling	MP	–
Average pooling	AP	–
Summation	Sum	–
Concatenation	Concat	–

C': Number of output channels
k: Receptive field size (kernel size)

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Recent Research - operator

- Forced Mutation
  - Random mutate at each nodes
  - At least one active node changes

- Neutral Mutation
  - Change only the genes of the inactive nodes without the modification of the phenotype

Our Goal

*Produce a **fast & accurate** CNN model*

of image classification on CIFAR-10

Approach

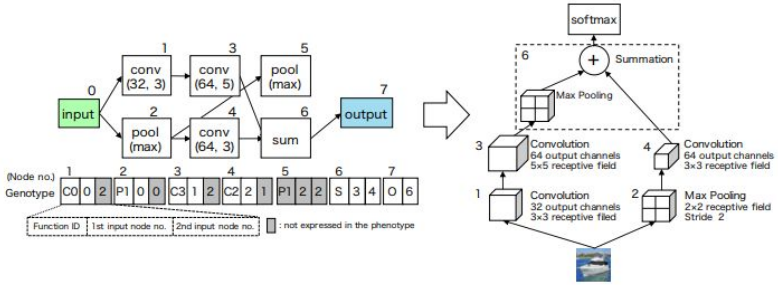
We are going to approach through the way of..

- Initialisation
- Representation
- Fitness Function / Fitness Evaluation
- Operator

Specific Approach - Initialisation

- Random Initialisation
  - GP-CNAS (graph): Ramped half and half
  - Random growth
  - Others..?
- From existing models
  - AlexNet, VGGNet, ResNet

Specific Approach - Representation



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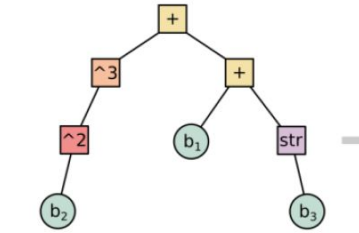
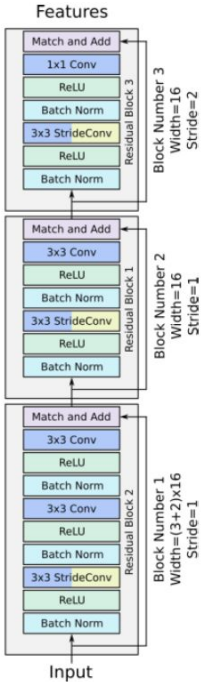


(+(^3(^2 b_2))(+b_1(str b_3)))



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ZHU, Yiheng, et al. GP-CNAS: Convolutional Neural Network Architecture Search with Genetic Programming. *arXiv preprint arXiv:1812.07611*, 2018.

Specific Approach - Fitness

We want to produce fast & accurate CNN model!

- Fitness evaluation = train + test
- Accurate: Set fitness as test accuracy
- Fast: Limit time budget of training time

Specific Approach - Operator

- Mutation :: How to develop from original mutation?
- Crossover :: How?
  - What kind of crossover? Type-aware crossover, Uniform crossover, Size-fair crossover, Sub-tree, ...
  - Where? One-point, sequences, trees
  - How many? Hmmm.. It will be decided with our experiments...
  - How...? How...? ... empirically ...

So... Would it really affect on our results?

It will be decided empirically...

Challenges

- **Time** — GP for CNN is time-consuming
- Constants — population size, time budget, ...
- CNN hyperparameters — learning rate, random seed, initializing, ...
- ...

Thank you!