Analysis and Design of Deep Neural Networks

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Fall 2022

Some Questions about the new course

1. What is the goal of the course “Analysis and Design of Deep Neural Networks”?
2. Why this course is necessary?
3. Which questions are answered through this course?
4. What are other benefits of using analysis and design methods in DNNs?
5. How can we analysis and design DNNs?

What is the main purpose of the course “Analysis and Design of Deep Neural Networks”?

- The main purpose of the course is to develop concepts, Metrics, and Indices which improve and ease the designing and learning process in DNNs.

Why “Analysis and Design of DNNs” is necessary?

1. The diversity of the proposed architectures for DNNs is considerably high. It is necessary to evaluate and rank them in a systematic way in order to know which ones are nearer to the optimal architecture with lower redundancy.

2. The main learning approach is a blind error-back propagation which suffers from sensitivity to initialization and getting stuck in local optimal points. It is necessary to develop learning methods which provide more interpretable and robust optimization ways.

3. The are not any systematic methods to evaluate, and rank pre-trained DNNS. In addition, we need more straightforward methods for compressing Networks, to ensemble some available networks or provide more reliable and generalized model.

4. There are some open problems such as feature representation, active learning, evolvable learning, one shot learning, multi-task learning which can be addressed and solved by new analyzing and designing methods .

Which questions may be answered by “Analysis and Design of Deep Neural Networks”?

- In Analysis and Design of DNNs, beyond the former conventional methods, we try to develop methods to answer following questions:
  1. How can we suggest better architectures of DNNs for a learning problem?
  2. How can we give geometrical interpretation about the functionality of a DNN.
  3. How can we evaluate the architecture and layers of a pre-trained DNN?
  4. How can we being sure that DNNs do not have any redundancy in their layers and units?
  5. How can we develop more interpretable methods in designing and learning DNNs?
  6. How can we compare different DNNs in accuracy and generalization?
  7. How can we give guarantee and confidence about the predictability of ours DNNs?
  8. How can we make a reliable defense strategy against attacks, Trojans and backdoors.

What are the benefits of using analysis and design for DNNs?

1. Analysis
   - Structural and Layer-wise Evaluation.
   - Data division and Augmentation to achieve better training and generalization
   - Ranking pre-trained DNNs in transfer-learning and find most suitable model.
   - Developing Guarantee and confidence indices for the predictability of DNNs.

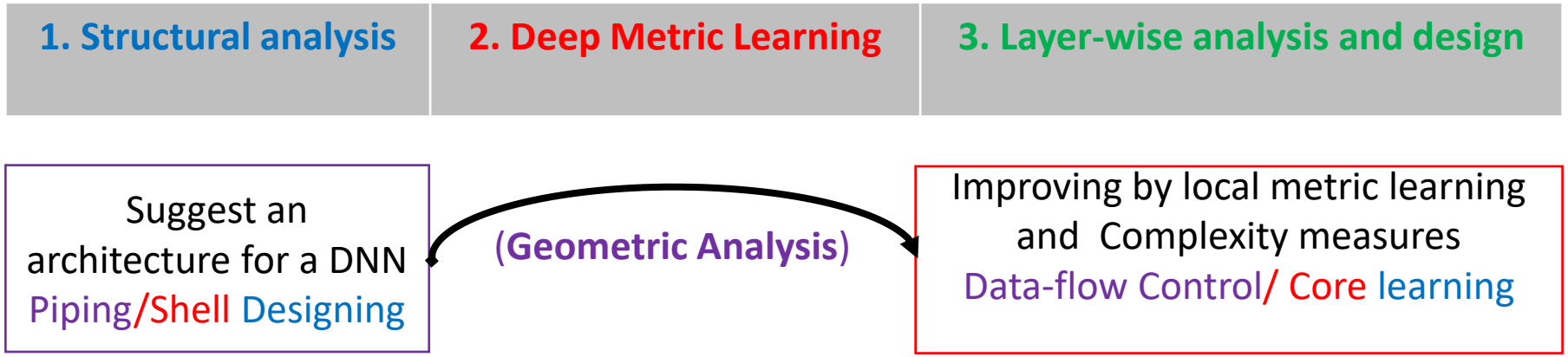
2. Design
   - Layer-wise pruning to achieve more compact form of DNNs
   - Layer-wise Learning to achieve faster and more accuracy
   - Layer-wise branching and designing more advanced architecture
   - Layer-wise fusion among some pre-trained DNNs.
   - Layer-wise self supervised learning.

How can we analysis and design DNNs?

1. Structure Analysis:
   - We can analyze and design by studying the functionality of layers, blocks and modules which define the architecture of DNNs
2. Deep Metrics Learning
   - We can develop some distance, angular, or other metrics and losses to have more relible and better learning in classification, and similarity learning problems.
3. Layer-Wise Design and Analysis
   - We can analysis and design DNNS be developing some complexity measures.

"Structural analysis" versus "Layer-wise analysis and design"

1. "Structural analysis" suggests a formal architecture for DNNs including topology, layers, blocks, and modules.
2. "Layer-wise analysis and design" improve the architecture and learn it by reducing a complexity measure.



Part1
Analysis and design by the formal functionality and architectures

1. Structure analysis in DNNs

1.1 Layers, Blocks and Modules

- Fully Connected layers and blocks
- Convolution Layers-Blocks-Modules
- Recurrent Layers – Modules
- Attention Layers – Modules
- Pooling layers
- Normalization Layers

1.2 Architectures

- CNNs
- Region Based CNNs (R-CNNs)
- DNNs for Segmentation
- Transformers

Part2
Geometrical analysis and design at the end layer (A Bridge to layer-wise...)

2. Deep Metric Learning

2.1 Introduction

- An introduction to Metric Learning
- An introduction to Similarity Learning

2.2 Deep Metric Learning

- Contrastive Loss (Siamese Networks)
- Triplet loss
- Circle Loss
- Softmax loss
- SphereFace(Angular-Softmax)
- CosineFace Loss
- ArcFace loss

Part3
Local metric learning by using complexity measures

3. Layer-wise Analysis and Design

3.1 Related works in local Layer-wise learning

- Implicit Semantic Data Augmentation for Deep Networks
- Greedy Layerwise Learning Can Scale to ImageNet
- Hebbian Semi-Supervised Learning in a Sample Efficiency Setting?
- Greedy InfoMax for Self-Supervised Representation Learning(GIM)
- A Simple Framework for Contrastive Learning of Visual Representations
- Pogressive Stage-wise Learning for Unsupervised Feature Representation Enhancement
- Layer-Wise Contrastive Unsupervised Representation Learning
- LoCo: Local Contrastive Representation Learning

3.2 Two Data Complexity measures

- Separation index
- Smoothness index

3.3 Layer-wise Analysis by Separation and Smoothness indices

- Dataset evaluation, ranking and dividing
- Subset Selection
- Layer-wise Model evaluation
- Pre-train Model ranking
- Some Ideas in Model Confidence and Guarantee

3.4 Layer-wise Design by Separation and Smoothness indices

- Model Compressing
- Forward learning in the first layer
- Layer-wise forward learning
- Layer-wise Forward Auto Encoder Learning
- Layer-wise branching and Fusion
- Some Ideas for Robust design against attacks, Trojans and backdoors

Course Evaluation

Section	Item #1	Item #2	Sum
Part 1	Homework1 (10%)	Study 1(10%)	20%
Part 2	Homework2(10%)	Study 2(10%)	20%
Part 3	Homework3 (10%)	Study 3(10%)	20%
Project	Final Project 20%		20%
Exam	Final Exam 25%		25%
Total			105%

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Team







https://addnn.github.io/

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The purpose of the Homework, Studies, and Final Project

----- Part1-------

Homework1: to suggest a better architecture of a DNN for a certain learning problem.

Study 1: to study and introduce new layers and architectures

---- Part2-----

Howework2 : to apply different known deep metric learning techniques for a certain learning problem.

Study 2 : to study new published works and introduce new deep metric learning developments

----- Part3-----

Howework3 : to use “SI: Separation Index” and “SmI: Smoothness Index” in evaluation of the layers of a certain pre-trained DNN or ranking different pre-trained DNNs

Study4: to study new published works about layer wise learning or complexity measures in DNNs

----Final Project

To apply one of the favorite analysis and design methods (or an idea) to a learning problem

End of Introduction