Analysis and Design of Deep Neural Networks

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Some Questions about the new course

1. What is the purpose 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 the benefits of using analysis and design 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, methods, 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 evaluate them in systematic way in order to know which ones are nearer to optimal architecture.
2. The main learning approach is error-back propagation and it suffers from sensitivity to initialization and getting stuck in local optimal points. It is necessary to develop learning methods which provide more interpretable optimization ways.
3. The are not any systematic methods to fuse, prune, and branch in DNNs through layers in order to optimize model.
4. There are some open problems such as re-configuration of neural networks, evolvable neural networks, and one shot learning which are necessary to be addressed in more appropriable ways .

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 have confidence about the predictability of a DNN?

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

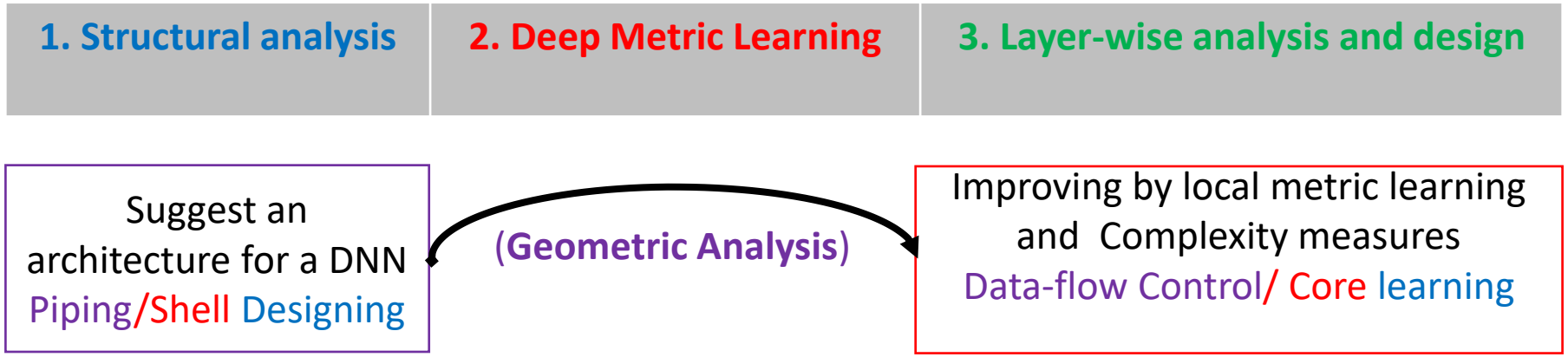
- Analysis
  - Structural and Layer-wise Evaluation
  - Data Division to achieve better generalization
  - Ranking pre-trained DNNs in transfer-learning
  - Developing Guarantee and confidence indices for the predictability of DNNs.
- Design
  - Layer-wise pruning to achieve more compact form of DNNs
  - 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

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 distance metric learning methods in geometrical based training of DNNs
3. Layer-Wise Design and Analysis
   - We can develop and layer-wise analysis and design be defining 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)
- CNNs for Segmentation
- Transformers

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

2. Deep Metric Learning

2.1. Metric Learning

- Mahalanobis Distance Metric

2.2. Deep Metric Learning

- Contrastive Loss — Siamese Networks
- Triplet loss — Triplet Networks
- Softmax loss
- A-Softmax loss
- Large Margin Cosine Loss (LMCL)
- Arcface loss
- Other losses

Part3
Local metric learning by using complexity measures

3. Layer-wise Analysis and Design

3.1 Former attempts in Layer-wise analysis and Design learning
- LoCo: Local Contrastive Representation Learning
- Heb-base, Clustering method
- Mutual Information method

3.3 Two Geometrical data Complexity measures
- Separation index
- Smoothness index

3.4 Experiences in Analysis and Design by Separation and Smoothness indices
- Model evaluation and ranking
- Model Compressing and Fusion
- Forward learning and design
- Model Confidence and Guarantee
- Attention mechanism

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 20%		20%
Total			100%

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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