1. Annotation

Course Description
The course is about Deep Learning, i.e. a new generation of neural network-based methods that have dramatically improved the performance of AI systems in such domains as computer vision, speech recognition, natural language analysis, reinforcement learning, bioinformatics. The course covers the basics of supervised and unsupervised deep learning. It also covers the details of the two most successful classes of models, namely convolutional networks and recurrent networks. In terms of application, the class emphasizes computer vision and natural language analysis tasks. The course involves a significant practical component with a large number of practical assignments.

Course Prerequisites
Linear algebra, Machine learning, confident mastery of Python coding basics.

2. Structure and Content

Course Academic Level
Master-level course suitable for PhD students

Number of ECTS credits
6
<table>
<thead>
<tr>
<th>Topic</th>
<th>Summary of Topic</th>
<th>Lectures (# of hours)</th>
<th>Seminars (# of hours)</th>
<th>Labs (# of hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed-forward neural networks</td>
<td>Hidden layers, deep feedforward networks, backpropagation, regularization ideas, batch normalization. Optimization for deep learning.</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Convolutional networks and applications in image analysis</td>
<td>Convolutional networks (CNNs), classifying images with CNNs, popular architectures and their design principles. Representations inside CNNs: visualizing networks, transfer learning, image retrieval with CNNs. &quot;Deep&quot; computer vision beyond classification: Verification tasks, object detection architectures, semantic segmentation Deep image generation: generating CNNs, adversarial networks, deep texture synthesis and artistic style. Autoencoders and variational autoencoders.</td>
<td>12</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Deep learning for natural language processing</td>
<td>Word embeddings, word2vec, convolutional networks for natural language processing.</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Recurrent neural networks and applications in natural language processing and trainable computing</td>
<td>Recurrent neural networks, deep learning on sequences, deep RNNs, LSTMs, GRUs, deep machine translation. Deep architectures with attention and long-term memory.</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Deep reinforcement learning</td>
<td>Deep Q learning, AlphaGo system</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Project</td>
<td>In-depth team project that applies deep learning to the problem/data of the students' choice.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

3. Assignments

<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Labs</td>
<td>Writing and training neural network in numpy.</td>
</tr>
<tr>
<td>Computer Labs</td>
<td>Implementing and training a high-performance convolutional network</td>
</tr>
<tr>
<td>Computer Labs</td>
<td>Implementing and investigating variational autoencoders and GANs</td>
</tr>
<tr>
<td>Computer Labs</td>
<td>Playing with natural language using recurrent networks+image captioning</td>
</tr>
<tr>
<td>Team Project</td>
<td>Propose and investigate experimentally new deep learning-related idea. Alternatively, reimplement and modify one of the recent papers</td>
</tr>
</tbody>
</table>
4. Grading

<table>
<thead>
<tr>
<th>Type of Assessment</th>
<th>Graded</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Grade Structure</th>
<th>Activity Type</th>
<th>Activity weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Homework Assignments</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Projects</td>
<td>30</td>
</tr>
</tbody>
</table>

Grading Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>86</td>
</tr>
<tr>
<td>B</td>
<td>76</td>
</tr>
<tr>
<td>C</td>
<td>66</td>
</tr>
<tr>
<td>D</td>
<td>56</td>
</tr>
<tr>
<td>E</td>
<td>46</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
</tr>
</tbody>
</table>

5. Basic Information

<table>
<thead>
<tr>
<th>Attendance Requirements</th>
<th>Optional</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Maximum Number of Students</th>
<th>Overall: 70</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Course Stream</th>
<th>Science, Technology and Engineering (STE)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Course Term (in context of Academic Year)</th>
<th>Term 4</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Course Delivery Frequency</th>
<th>Every year</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Students of Which Programs do You Recommend to Consider this Course as an Elective?</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Masters Programs</th>
<th>PhD Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Science</td>
<td>Computational and Data Science and Engineering</td>
</tr>
</tbody>
</table>

Please List the Teaching Assistants (TAs) You Propose for Your Course

<table>
<thead>
<tr>
<th>First Name</th>
<th>Last Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victor</td>
<td>Kulikov</td>
</tr>
<tr>
<td>Dmitry</td>
<td>Ulyanov</td>
</tr>
<tr>
<td>Evgenia</td>
<td>Ustinova</td>
</tr>
<tr>
<td>Egor</td>
<td>Burkov</td>
</tr>
<tr>
<td>Egor</td>
<td>Zakharov</td>
</tr>
</tbody>
</table>

| Course Tags | |
|-------------||

6. Textbooks and Internet Resources

<table>
<thead>
<tr>
<th>Recommended Textbooks</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Web-resources (links)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://vision.stanford.edu/teaching/cs231n/">http://vision.stanford.edu/teaching/cs231n/</a></td>
<td>Stanford class on convolutional networks</td>
</tr>
<tr>
<td><a href="http://web.stanford.edu/class/cs224n/">http://web.stanford.edu/class/cs224n/</a></td>
<td>Stanford class on deep learning for natural language processing</td>
</tr>
<tr>
<td><a href="http://ru.eclass.cc/courselists/117_deep_learning">http://ru.eclass.cc/courselists/117_deep_learning</a></td>
<td>Deep Learning @Eclass: all about online learning</td>
</tr>
</tbody>
</table>

7. Facilities

<table>
<thead>
<tr>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linux Ubuntu 16.04</td>
</tr>
<tr>
<td>Python 3.5 + iPython</td>
</tr>
<tr>
<td>PyTorch 1.0 or newer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audience, computer class)</td>
</tr>
<tr>
<td>Syllabus documents and materials on the topics of discipline.</td>
</tr>
<tr>
<td>The library, including electronic publications.</td>
</tr>
<tr>
<td>Access to the Internet through a computer class and Wi-Fi network of the institute.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Labs for Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Lab (TPOC3: 404)</td>
</tr>
</tbody>
</table>

8. Learning Outcomes

<table>
<thead>
<tr>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Know the algorithmic foundations of deep learning, including state-of-the-art variants of stochastic gradient descent and architectural peculiarities of modern convolutional and recurrent neural networks.</td>
</tr>
<tr>
<td>Be aware of the recent progress of deep learning concerned with image analysis, computer vision, and natural language analysis applications.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototype, train, and apply deep learning architectures, including architectures involving transfer knowledge from pretrained models, models with new layers.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify and design new deep network architectures suitable for non-standard machine learning tasks and applications.</td>
</tr>
<tr>
<td>Use deep learning packages such as PyTorch and other relevant Python packages.</td>
</tr>
</tbody>
</table>
Do you want to specify outcomes in another framework? Knowledge-Skill-Experience is good enough

<table>
<thead>
<tr>
<th>9. Assessment Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Select Assignment 1 Type</strong></td>
</tr>
<tr>
<td><strong>Input Example(s) of Assignment 1 (preferable)</strong></td>
</tr>
<tr>
<td><strong>Assessment Criteria for Assignment 1</strong></td>
</tr>
</tbody>
</table>

| **Select Assignment 2 Type** | Final Exam |
|-------------------------------|
| **Input Example(s) of Assignment 2 (preferable)** | Final project presentation and reports. Examples of the project topics selected by the students: “A simple chat-bot trained on movie subtitles”, “A network that rectifies photos with slanted horizon”, “Autoencoders with artistic loss functions for image generation” |

10. Additional Notes