DL4nlp - Deep Learning for Natural Language Processing

Ander Barrena Madinabeitia
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Hitz Zentroa - Ixa Taldea

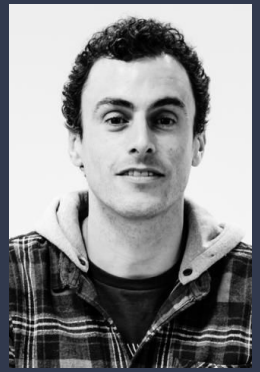
Slides available in repo!

Lab Time!

From LR to Transformers

Task: Sentiment analysis

About myself



- PhD in Natural Language Processing in 2017 (EHU) Machine Learning! (old stuff!)
  - PGM and Generative Statistical Models
  - Personalized Page Rank
- post-Doctoral grant from EHU (Deep Learning)
- assistant professor in EHU
- research interest:
  - **Multilingual/Unsupervised Named Entity Disambiguation**
  - Sequence Labeling, **Language Modeling (Basque, Medical domain)**, QA, Semantic Textual Similarity, Information Extraction...
  - Deep Learning for NLP
  - **Brain Image Classification based on Transformers**
    - Dyslexia
    - Alzheimer
    - ...

About myself

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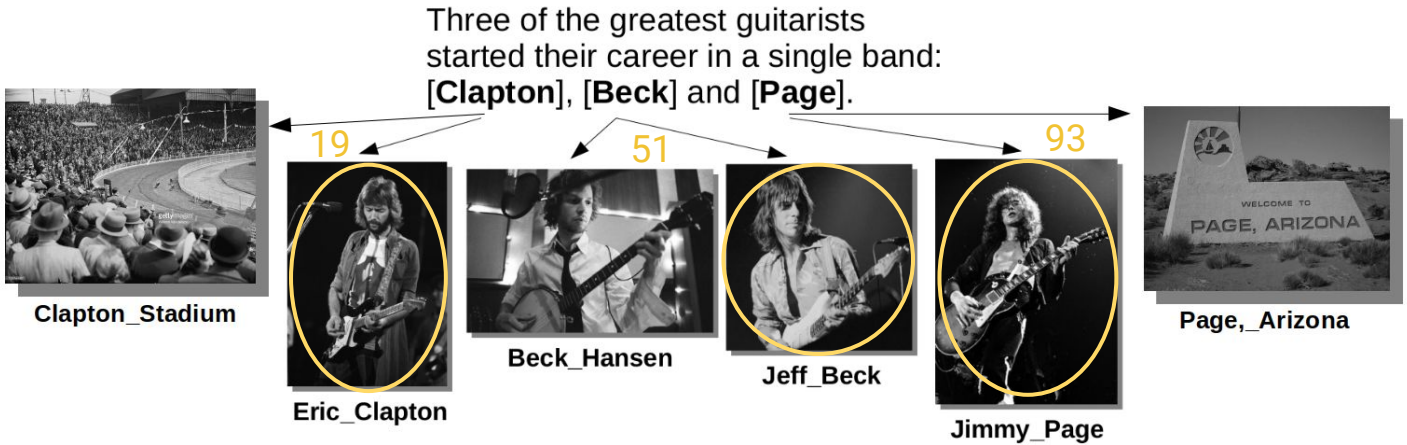

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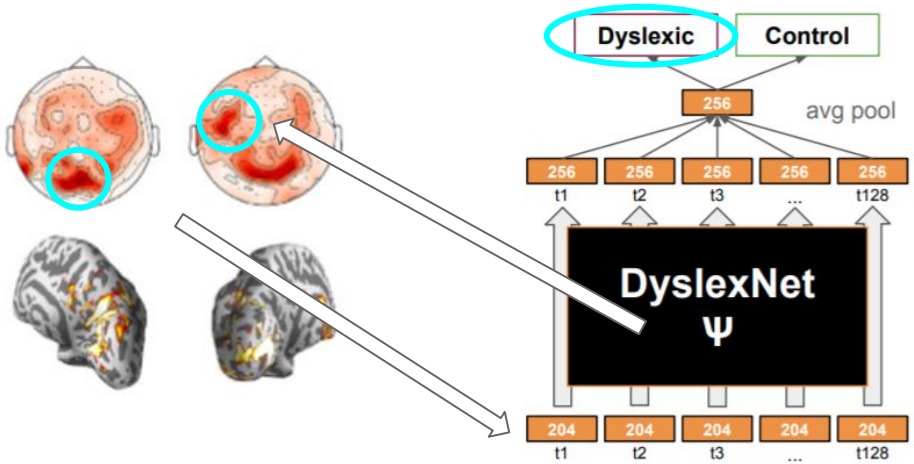

46[sub] x 3k[instances] x **128[time] x 204[activations]**

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TensorFlow!

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- Rise your hand and ask your question
- Try not to use chat (only for you)
- Private room (share your screen...)
  - small talks...

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Lab1:
Warming Up
+ assignment
-> sol. next lab

Lab1: Warming Up

- Follow the instructions in 0.Instructions.docx to access the lab data.
- Goal: Ensure everithing is working fine.
  - Python (list comprehension)
  - Numpy (vector multiplications)
  - TensorFlow 2.0
  - Loading/Examining data from labs folder
    - Train/Dev/Test splits
  - 2 goals -> numpy and TF2.0
- Code in Jupiter Colab & self-explanatory labs.
- We recommend you the python/numpy tutorial and to take a look to the slides.

Please! play with the code!

Change numbers and print each step vector size!

Run code more than once!

Lab1: Warming Up

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  - Numpy
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  - 2 assignments numpy and TF2.0
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$$\frac{1}{\sqrt{2\sigma^2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Today's Goal!
Function Broadcasting!

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Attendance certificate
Progress certificate (all labs, not assignments) send it before showing the solution

Good luck!

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lab1 until 18:30!

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Assignment1: Logistic Regression, SGD, and Regularization

Assignment1: Logistic Regression, SGD, and Regularization

- Logistic Regression model for sentence classification using Tensorflow.
- Task: Sentiment analysis
- 5-way classification task into 2-way classification task (0→negative, 1→positive)
- Goals:
  - Pick an effective learning rate for SGD
  - Implement L2 regularization (see bellow)
  - Pick an effective L2 weight
  - Look at some learning curves (optional)
- Check:
  - BoW feature vector
  - Num of parameters?
  - Hyperparameters?
  - Norm and Exp
  - mini Batch
  - data spliting
  - ...

Assignment1: Logistic Regression, SGD, and Regularization

- Logistic Regression model for sentence classification using Tensorflow.

$$h = \exp(xW + b)$$

```
def model(x):
  logits = tf.matmul(x, W) + b
  h = tf.exp(logits)
```

- **Overfitting and regularization:** W can be very good for training, with enough layers and capacity the model can memorize the training data!
  - Generalize very poorly to test data (= the real world)
- First solution: add a regularizer to the loss function that avoids the model to fit the training data.
  - Squared L2 norm

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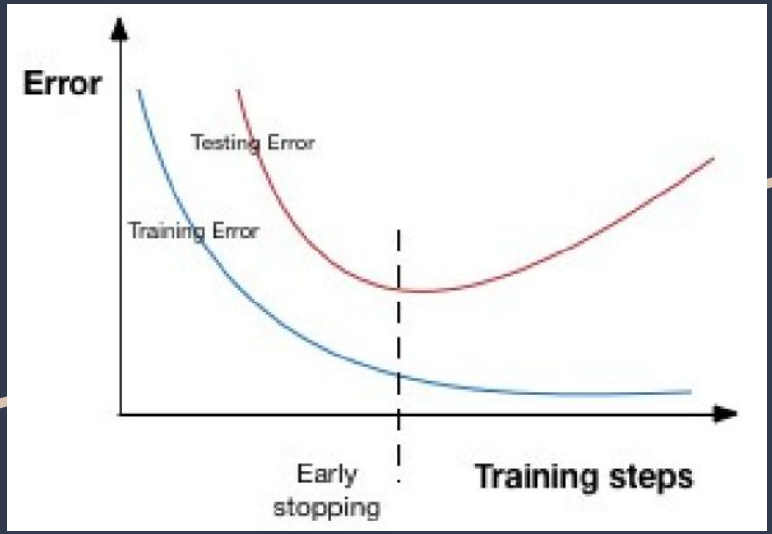
$$J_i(W) = -\log\left(\frac{\exp\left(W_{c_i}^T x\right)}{\sum_{c' \in C} \exp\left(W_{c'}^T x\right)}\right) + \lambda \sum_k W_k^2$$

Check the TF documentation! for sum and square

Assignment1: Logistic Regression, SGD, and Regularization



- Logistic Regression model for sentence classification using Tensorflow.
- **Overfitting and regularization:** W can be very good for training, with enough layers and capacity the model can memorize the training data!
  - Generalize very poorly to test data (= the real world)
- **First solution:** add l2 regularizer to the loss function that avoids the model to fit the training data.
- **Second solution:** Early stopping finishes training as soon as development error starts to increase
  - **Experimental setup:**
    - %80 train, %10 development, %10 test (blind!!)
  - **Model selection:**
    - best accuracy (lowest error) at development

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Good luck!
Sol. next Lab!

Don't send me the assignment!

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Solution & Lab Time!

- New Private Room:
  - https://ehu.webex.com/meet/abarrena
  - enter only when necessary

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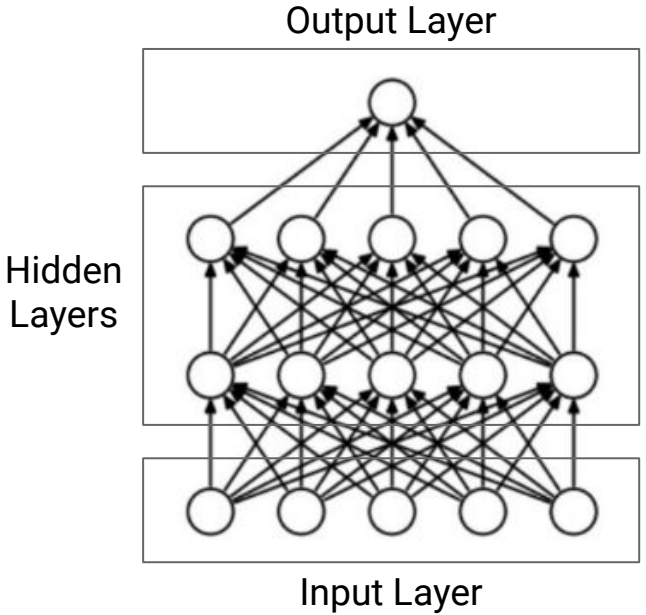
Lab2: MLP and Dropout

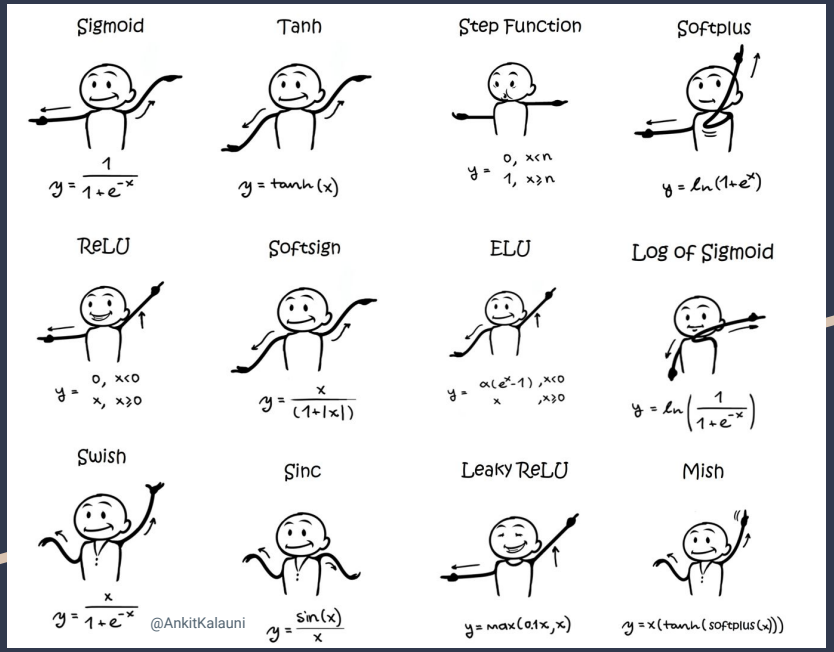
Lab2:
MLP and Dropout

- Modify a Logistic Regression to turn it into a MLP with two hidden layers (non-linearity).
  - 2 hidden layers = Deep Learning...
- It will **overfit** in training data! (toy examples)



Lab2:
MLP and Dropout

Dance moves of DL activations



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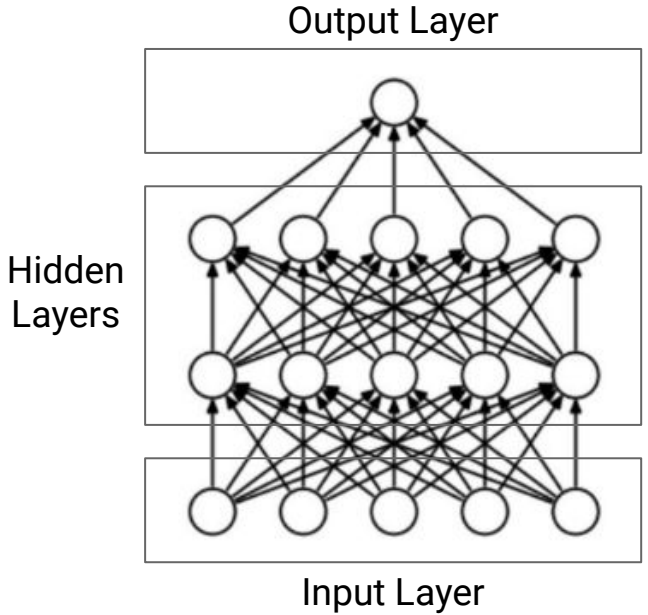

Today's Goal!

Lab2:
MLP and Dropout

$$y = softmax(h_1 W_2 + b_2)$$

$$h_1 = f(h_0 W_1 + b_1)$$

$$h_0 = f(x W_0 + b_0)$$

- Modify a Logistic Regression to turn it into a MLP with two hidden layers (non-linearity).
  - 2 hidden layers = Deep Learning...
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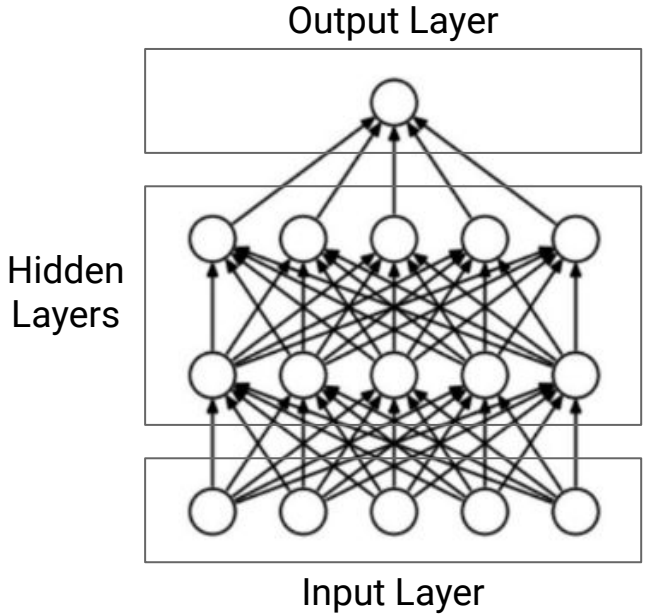

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Lab2:
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$$y = softmax(h_1 W_2 + b_2)$$

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Sentence Representation
(word order?)

Word Embeddings

- Modify a Logistic Regression to turn it into a MLP with two hidden layers (non-linearity).
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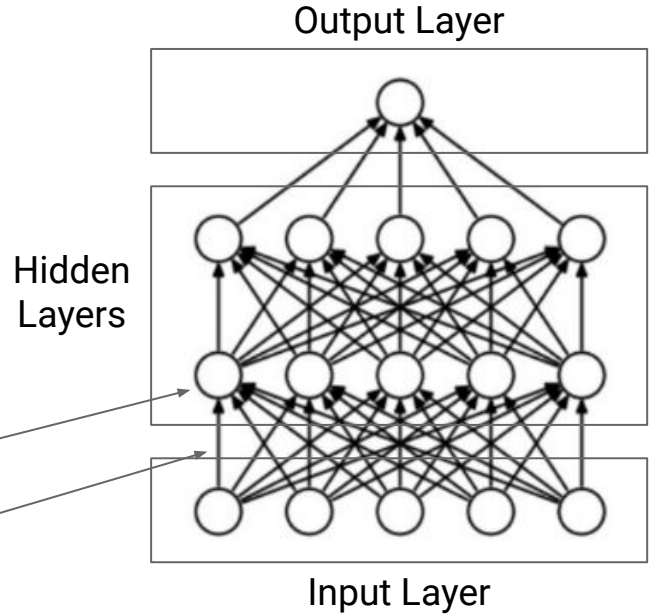
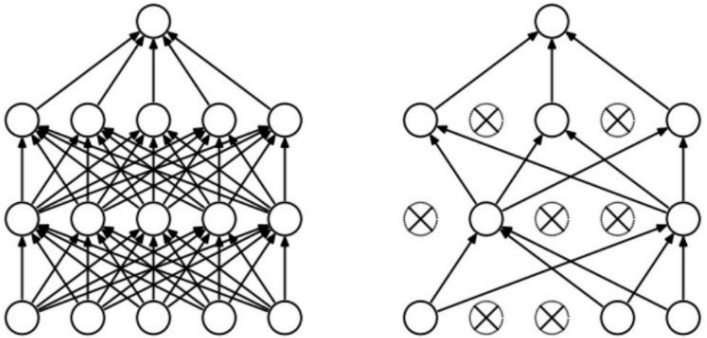
- It will **overfit** in training data!



Today's Goal!

Lab2:
MLP and **Dropout**

- Modify a Logistic Regression to turn it into a MLP with two hidden layers (non-linearity).
- It will overfit in training data!
- Add **Dropout** regularization. Hint: after non-linearity and only during training.



(a) Standard Neural Net (b) After applying dropout.

Source: “Dropout: a simple way to prevent neural networks from overfitting”, JMLR 2014

Lab2:
MLP and Dropout

- Modify a Logistic Regression to turn it into a MLP with two hidden layers (non-linearity).
- It will overfit in training data!
- Add **Dropout** regularization. Hint: after non-linearity and only during training.
- More parameters to tune!
    - Hidden layer number and size. The more the better? not always...
    - Dropout Probability.
    - Should we add dropout in the input layer?
    - Early stop?
        - Check where should we stop training and save the best model

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MLP and Dropout

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Be careful with dropout at test time

Be careful with dimensionalities

Be careful with the initialization! Gradient Vanishing!

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MLP and Dropout

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Shared task! Share your **dev**/test results and best model hyperparameters and dimensionality

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MLP and Dropout

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- More parameters to tune!
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  - Dropout Probability.
  - Should we add dropout in the input layer?
  - Early stop?

Once you are done, try 5 way classification... code your own learning rate decay... increase vocab....

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Good luck!
Sol. next Lab!

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Solution & Lab Time!

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Download again the lab!
Use chrome or Firefox...

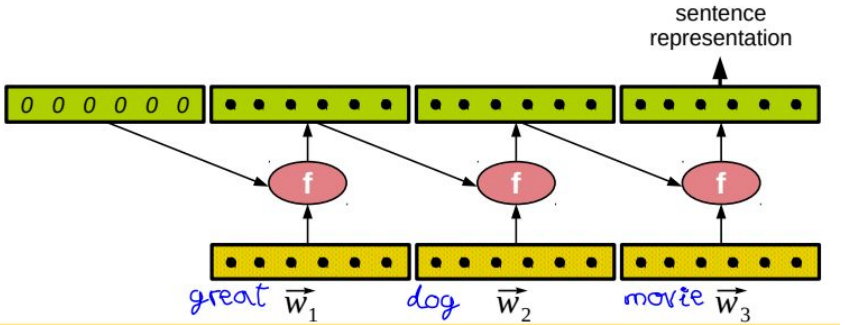
Lab3: RNN based classifier

Lab3:
RNN based classifier

Hints:

- Use tf.nn.embedding_lookup
- Print shapes: tf.shape()
  - batch x input…
  - batch x hidden…
- Be patient…
- We already add l2 regularization…
- Improving dev at 250~300 ep
  - ~73% acc. (ep 265)

- Modify a Logistic Regresion to turn it into a RNN sentence classifier.
- Slower that MLP, and not very good… yet!
- Define **RNN** parameters (Recurrent layer)
- Define a recurrent step
  - Embedding_lookup
  - Concat
  - matmul & Tanh!
- Unroll to obtain sentence representation!
  - Loop over the sequence_lenght and use x_slices
  - Be careful with shapes! tf.reshape!
  - Perform an step
- Once you are done:
  - You can add an MLP on top!
  - bidirectional ….



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Assignment2: Word Embeddings

Assignment2: Word Embeddings!

- Cosine Similarity: Similar and related Words
- Semantic orientation
- Analogy
  - man -> king
  - woman -> ???
- Visualization tools
- Have a good time after **RNN** lab!

Similar and related Words

	jesus (3994)		
1	jesus	3993	1.0000
2	christ	4904	0.8533
3	god	1533	0.7633
4	resurrection	16493	0.7583
5	crucifixion	27882	0.7296
6	divine	8661	0.7133
7	blessed	10141	0.6988
8			
9			
10			
11			
12			
13			
14			
15			

Analogy

	france - paris + italy		
1	rome	2618	0.8547
2	italy	931	0.8122
3	paris	1035	0.7886
4	milan	2777	0.7841
5	turin	9084	0.7740
6	venice	8081	0.7665
7	madrid	2471	0.7639
8	italian	1031	0.7586
9	aires	7131	0.7501
10	naples	9611	0.7478
⋮	⋮	⋮	⋮
400000	tarkas	323931	-0.7629

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Solution & Lab Time!

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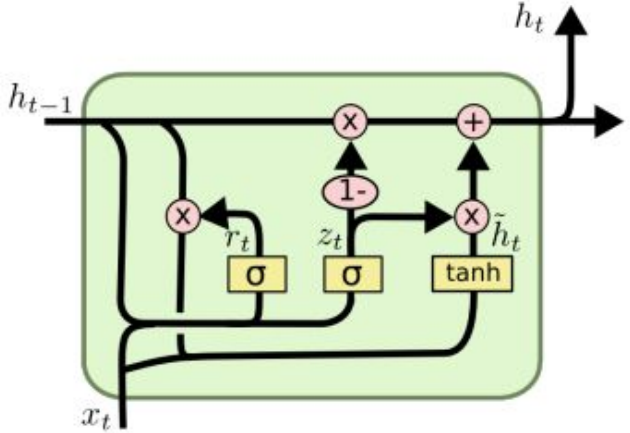
Lab4: GRU based classifier

Lab4:
GRU based classifier

Kyunghyun Cho (2014)

- Modify a RNN to GRU.



Lab4:
GRU based classifier

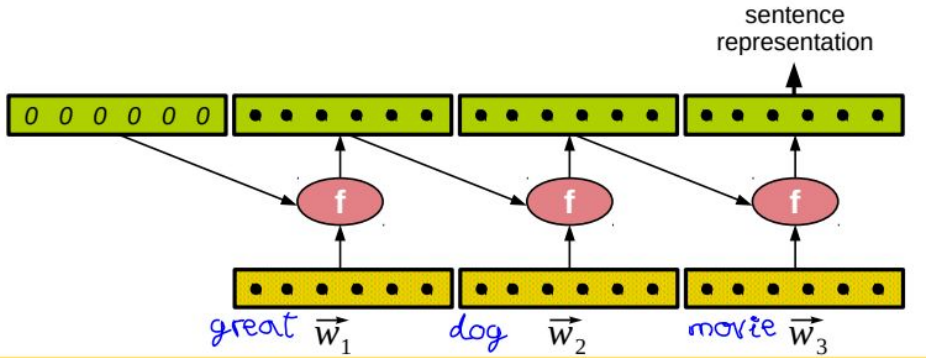
$$z_t = \sigma\left(W_z \cdot [h_{t-1}, x_t]\right)$$ Update

$$r_t = \sigma\left(W_r \cdot [h_{t-1}, x_t]\right)$$ Reset

$$\tilde{h}_t = \tanh\left(W \cdot [r_t * h_{t-1}, x_t]\right)$$

$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

- Modify a RNN to GRU.
  - Add aditional parameters
  - Modify the step function
  - Modidy L2 regularization
  - Wait 100~150 epochs… be patient
    - dev acc ~80% !!!
  - Plot dev/train acc
    - Check when do we need to early stop
  - Code LSTM or Stack GRU layers



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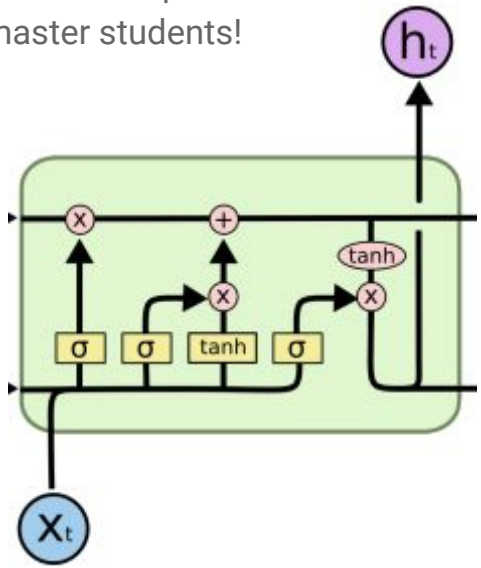
Assignment3: Language Modelling with LSTM networks

Assignment3: LSTM based classifier

- Modify a RNN to LSTM, perform **language modeling task** and answer some questions.
- Language Modeling, new task, new cost function…
- Same as GPT3 but using LSTMs an at low scale…
- Language Generation: Samples from a trained models should have “coherent” portions.
- Note that this is for master students!



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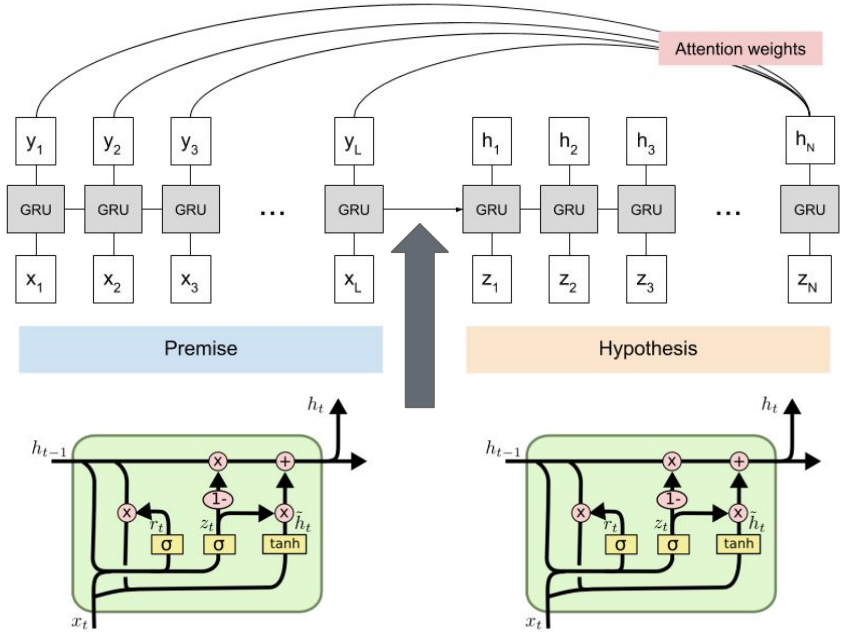
Lab5: Attention models

Lab5: Attention models

- Attention model for NLI based on Rocktäschel's model. (Read the paper...)
- Natural Language Inference (NLI). Given a pair of premise and hypothesis texts, the task is to classify them into three categories: entailment, contradiction, and neutral.
  - A man inspects the uniform of a figure in some East Asian country. | **contradiction** | The man is sleeping.
  - A soccer game with multiple males playing. | **entailment** | Some men are playing a sport.
  - An older and younger man smiling. | **neutral** | Two men are smiling and laughing at the cats playing on the floor.
- This is deep learning! (a scientific paper reimplementation)

Lab5: Attention models

- Attention model for NLI based on Rocktäschel's model.
  - 2xGru encoders + attention (no bias)



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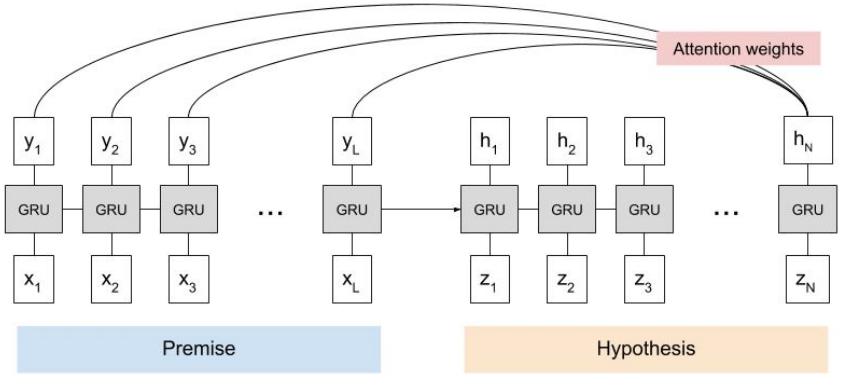

$$\mathbf{M} = \tanh(\mathbf{W}^y \mathbf{Y} + \mathbf{W}^h \mathbf{h}_N \otimes \mathbf{e}_L)$$

$$\alpha = \text{softmax}(\mathbf{w}^T \mathbf{M})$$

$$\mathbf{r} = \mathbf{Y}\alpha^T$$

$$\mathbf{h}^* = \tanh(\mathbf{W}^p \mathbf{r} + \mathbf{W}^x \mathbf{h}_N)$$

Goal!

Lab5: Attention models

- Attention model for NLI based on Rocktäschel's model.
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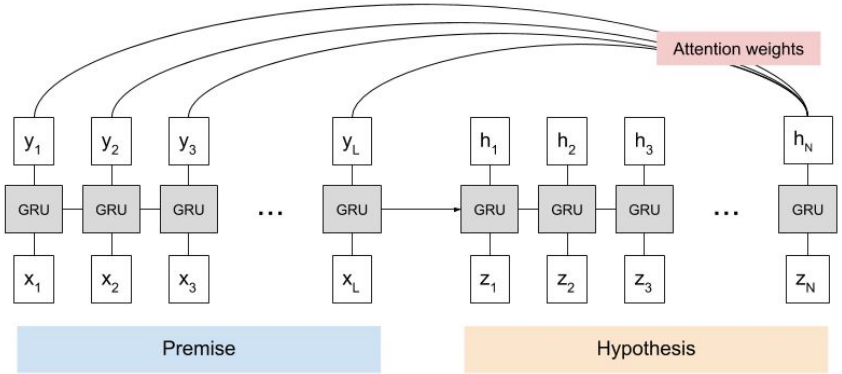

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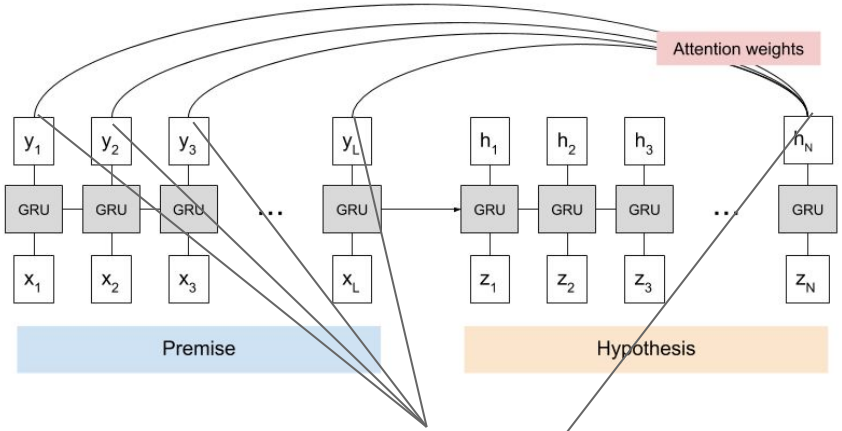
$$\mathbf{r} = \mathbf{Y}\alpha^T$$

$$\mathbf{h}^* = \tanh(\mathbf{W}^p \mathbf{r} + \mathbf{W}^x \mathbf{h}_N)$$

Hint! iterate over Y

Lab5: Attention models

- Attention model for NLI based on Rocktäschel's model.
  - 2xGru encoders + attention (no bias)



$$\mathbf{M} = \tanh(\mathbf{W}^y \mathbf{Y} + \mathbf{W}^h \mathbf{h}_N \otimes e_L)$$

$$\alpha = \text{softmax}(\mathbf{w}^T \mathbf{M})$$

$$\mathbf{r} = \mathbf{Y}\alpha^T$$ avg. representation

$$\mathbf{h}^* = \tanh(\mathbf{W}^p \mathbf{r} + \mathbf{W}^x \mathbf{h}_N)$$ → ???

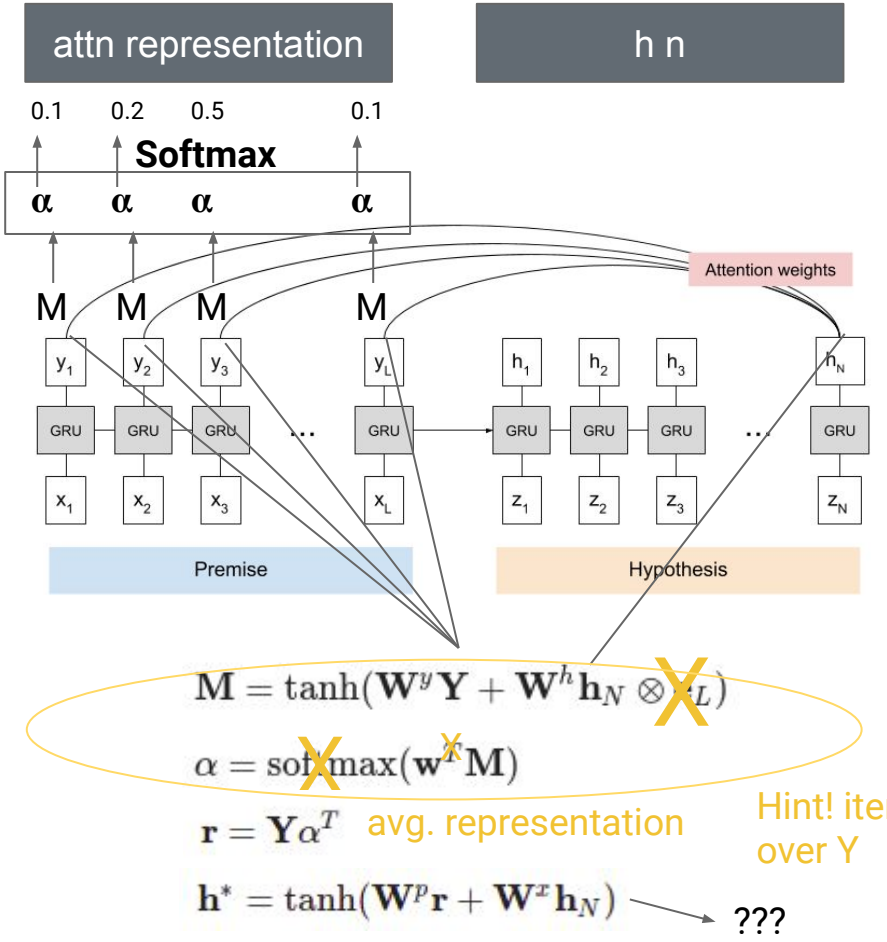
Hint! iterate over Y

Lab5: Attention models solution

Hints:

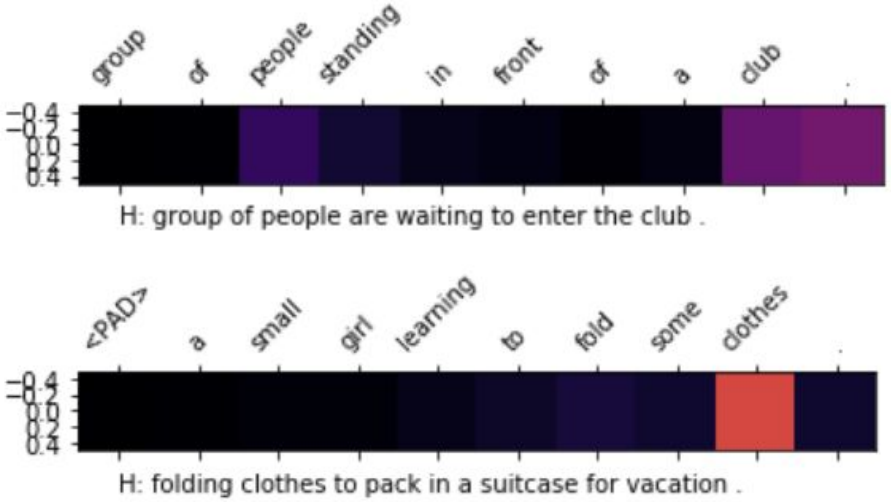
- Iterate over premise representations Y & matmul Wy
- sum “h_n matmul Wh” to each one
- Apply tanh -> M
- M matmul W & Softmax

Print Shapes!!!



Lab5: Attention models

- Attention model for NLI based on Rocktäschel's model.
  - 2xGru encoders + attention (no bias)
  - Fixed and freezed embeddings (from Glove)
  - GPU! (enable in runtime) still slow training…
  - Don't expect high accuracy
- Once you are done
  - Plot attention weights



Lab5: Attention models

- Attention model for NLI based on Rocktäschel's model.
  - 2xGru encoders + attention (no bias)
  - Fixed and freezed embeddings (from Glove)
  - GPU!
  - This is deep learning!
- Once you are done
  - Plot attention weights
  - Back propagate through embeddings (more parameters...)
  - Increase hidden size, embedding size (dowload Glove embeddings)...
  - Try to increase model accuracy! (However, it takes too long...)

DL4nlp - Deep Learning for Natural Language Processing

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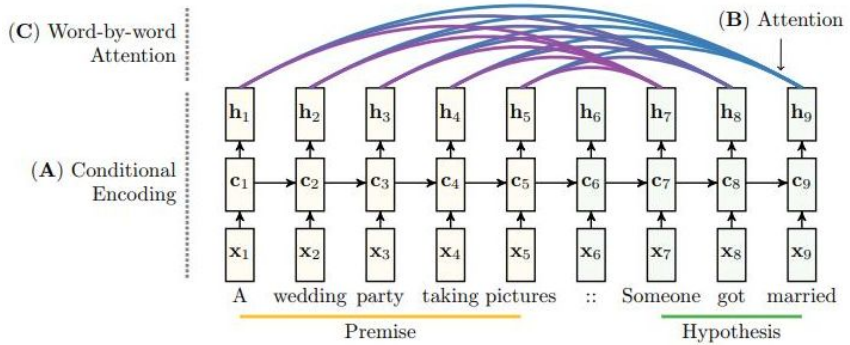
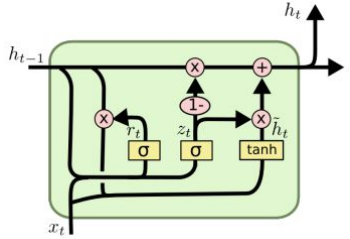
Assignment4: Word by Word attention

Assignment4: Word by Word attention

- Attention model for NLI based on Rocktäschel's model.
  - 2xGru encoders + Word by Word attention





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Good luck!
Sol. next Lab!

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Solution & Lab Time!

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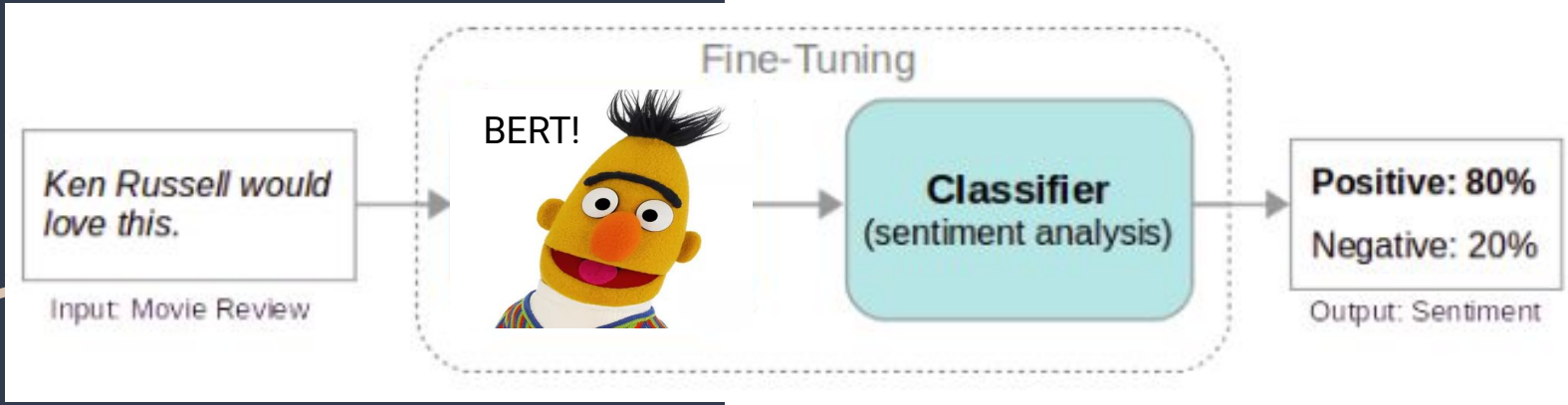
Lab5: Transformers with TensorFlow

Lab5: Transformers with TensorFlow

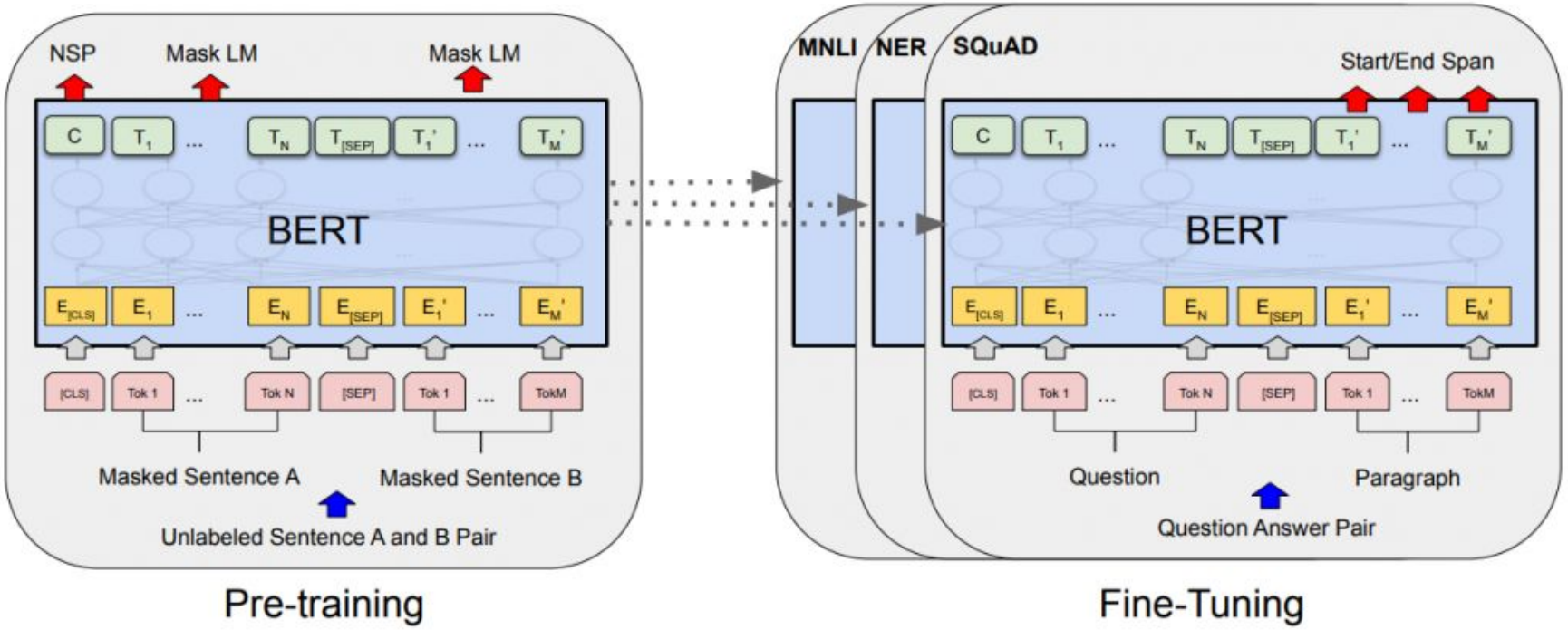
- Fine-tune a Transformer based pre-trained language models.
  - 3 or 4 epochs!
  - we introduce:
    - keras
    - huggingface transformers

Black box!



Lab5: Transformers with TensorFlow

- **BERT** pretraining: **MLM & NSP** and **Fine-tuning**



Lab5: Transformers with TensorFlow

- Fine-tune a Transformer based pre-trained language models.
  - 2, 3 or 4 epochs!
- More concretely, in this lab session will learn the following:
  - Deploy and fine-tune transformers (**BERT**).
  - Transfer learning!
  - Preprocessing data for transformers archicture (word piece tokenization)
  - **soa** Transformer-based classifier
    - High test Acc -> **0.90!!**
  - Finetune for NLI:
    - **Hint:** Zip and List Comprehension + batch_encode_plus

Lab5: Transformers with TensorFlow

Once you are done:

- Try training with **XLMR (crossling model)**
- Run in other datasets or tasks
- Test with sentences in other languages

- Fine-tune a Transformer based pre-trained language models.
  - 2, 3 or 4 epochs!
- More concretely, in this lab session will learn the following:
  - Deploy and fine-tune transformers (**BERT**).
  - Transfer learning!
  - Preprocessing data for transformers archicture (word piece tokenization)
  - **soa** Transformer-based classifier
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  - Finetune for NLI:
    - **Hint:** Zip and List Comprehension + batch_encode_plus

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Good luck :D

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Solution &
Last Lab :(

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Lab6: Image Captioning

Lab6: Image Captioning

- Given an image like the example below, our goal is to generate a caption such as "**a surfer riding on a wave**". (cherry picking! :P)

- Toy examples = bad captions!
- Attention maps!
- Try on your on images

Lab6: Image Captioning

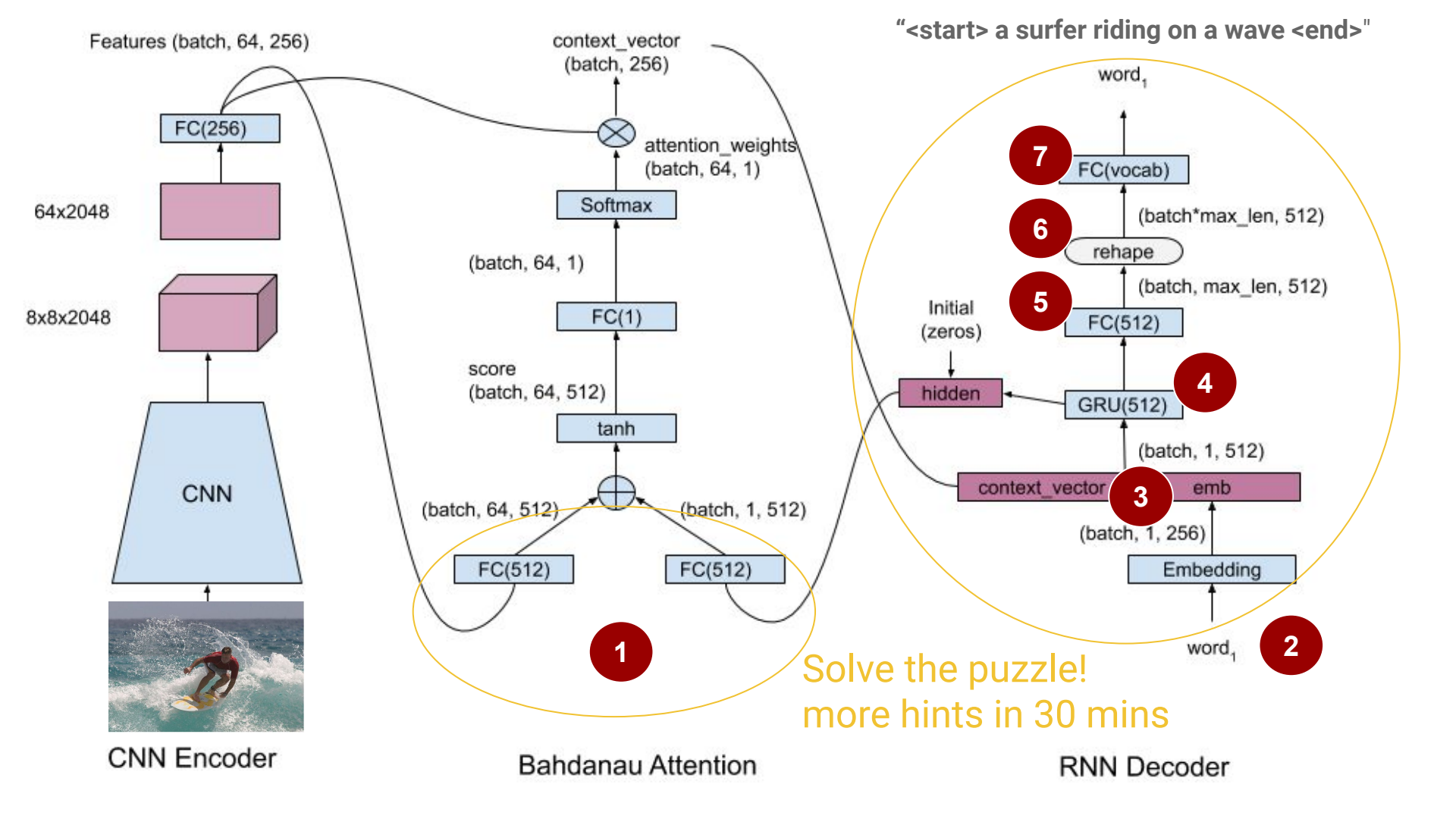
```
model = Sequential()
model.add(Dense(50,
input_shape=input_shape, activation='relu'))
model.add(Dense(50, activation='relu'))
model.add(Dense(num_classes,
activation='softmax'))
```

```
model.compile(loss='categorical_crossentrop
y', optimizer='adam', metrics=['accuracy'])
model.fit(X_train, Y_train, epochs=10,
batch_size=250, validation_split=0.2)
```

```
test_results = model.evaluate(X_test, Y_test,
verbose=1)
```

- Keras
  - **add layers into a MLP**
    - model.add(layers.Dense(64, activation='relu'))
  - **use GRU**
    - gru = tf.keras.layers.GRU(4)
      - output = gru(inputs)

- CNN image encoder (pre-trained!)
- GRU-RNN text decoder
- Attention (image & text)
- Multimodal task
- Transfer learning (InceptionV3 for image classification)
- Image and text preprocessing cells…
- Checkpoints!


"<start> a surfer riding on a wave <end>"
Features (batch, 64, 256)
FC(256)
64x2048
8x8x2048
CNN
CNN Encoder
context_vector
(batch, 256)
attention_weights
(batch, 64, 1)
Softmax
(batch, 64, 1)
FC(1)
score
(batch, 64, 512)
tanh
(batch, 64, 512)
(batch, 1, 512)
FC(512)
FC(512)
1
Bahdanau Attention
word1
7
FC(vocab)
(batch*max_len, 512)
6
rehape
(batch, max_len, 512)
5
FC(512)
Initial
(zeros)
hidden
GRU(512)
4
(batch, 1, 512)
context_vector
3
emb
(batch, 1, 256)
Embedding
word1
2
RNN Decoder
Solve the puzzle!
more hints in 30 mins

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Good luck!