Deep Learning with Unstructured Text

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Overview

- Unstructured Text & GIS
- Natural Language Processing
- Text Models in ArcGIS API for Python
- Model Architecture
  - Transformers Basics
  - Attention Mechanism
- Trainable Models
  - **EntityRecognizer, SequenceToSequence, TextClassifier**
- Inference Only Models
  - **ZeroShotClassifier, TextSummarizer, TextTranslator, QuestionAnswering, TextGenerator, FillMask**
- Summary
- Resources to learn more
- Feedback

Unstructured Text & Geospatial Data

- **Unstructured text** is written content that
  - Lacks structure.
  - Cannot be indexed or mapped onto standard database fields.
- **Unstructured text** is often comprising of user-generated content such as
  - Books
  - Journals
  - News Article
  - Social Media Posts
- **Geospatial data** is not available in the form of
  - Maps and feature/imagery layers
  - Unstructured text (can contain location information which makes them geospatial data).

Natural Language Processing

- Field of computer science that deals with
  - Processing and analyzing natural language text.
  - Extracting information and insights contained in documents
  - Categorizing and Organizing documents.
  - Understanding the contextual nuances of the language in a document
- Common NLP Tasks
  - Text Classification
  - Named Entity Recognition
  - Machine Translation
  - Text Summarization
  - Question Answering
  - Text Generation

Text Models in ArcGIS API for Python

Text models available in arcgis.learn.text module falls under 2 categories

- Trainable Models
  - Requires training on a given dataset before they can be used for inferencing.
  - Follows the similar style as with rest of the models available in arcgis.learn module.
- Inference-Only Models
  - Doesn't need to be trained and can be used directly for inferencing purpose.
  - Doesn't have methods like *fit(), lr_find(),* etc. which are required to train models in arcgis.learn module.

Model Architecture

- Existing models in arcgis.learn.text module are based on Hugging Face Transformer Library.
- The Transformers are novel architectures that aim to solve.
  - Task of translating an input sequence to an output sequence (of any length)
- The library provides general-purpose transformer architectures
  - Like BERT, RoBERTa, DistilBert, XLNet, T5, GPT-2 etc.
  - Gives state of the art results for a wide range of NLP tasks like
    - Sequence classification, Named Entity Recognition (NER), Machine Translation, Text Summarization, etc.
  - 32+ pretrained models in 100+ languages.

Relevant links

- Summary of models in Hugging Face Transformers Library - https://huggingface.co/transformers/summary.html
- Hugging Face Transformers library model zoo - https://huggingface.co/models

Transformers Basics

A transformer consists of

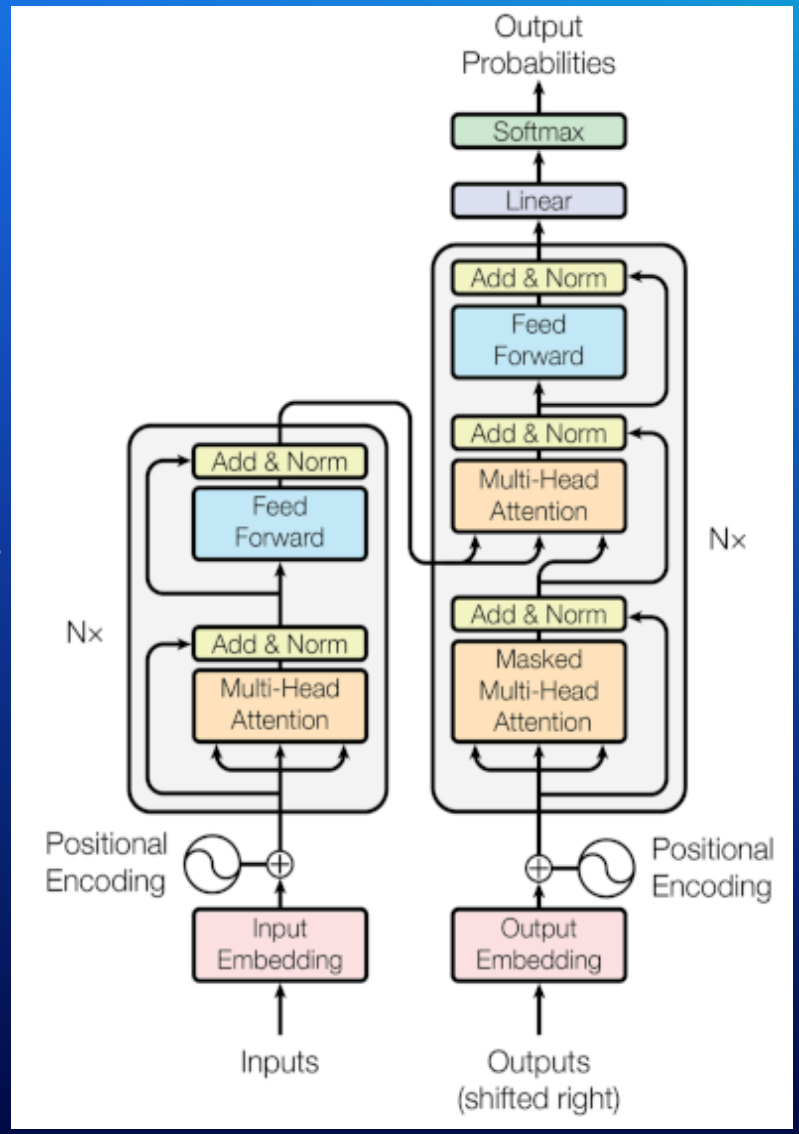
- An **encoding component** (stack of encoders)
- A **decoding component** (stack of decoders)

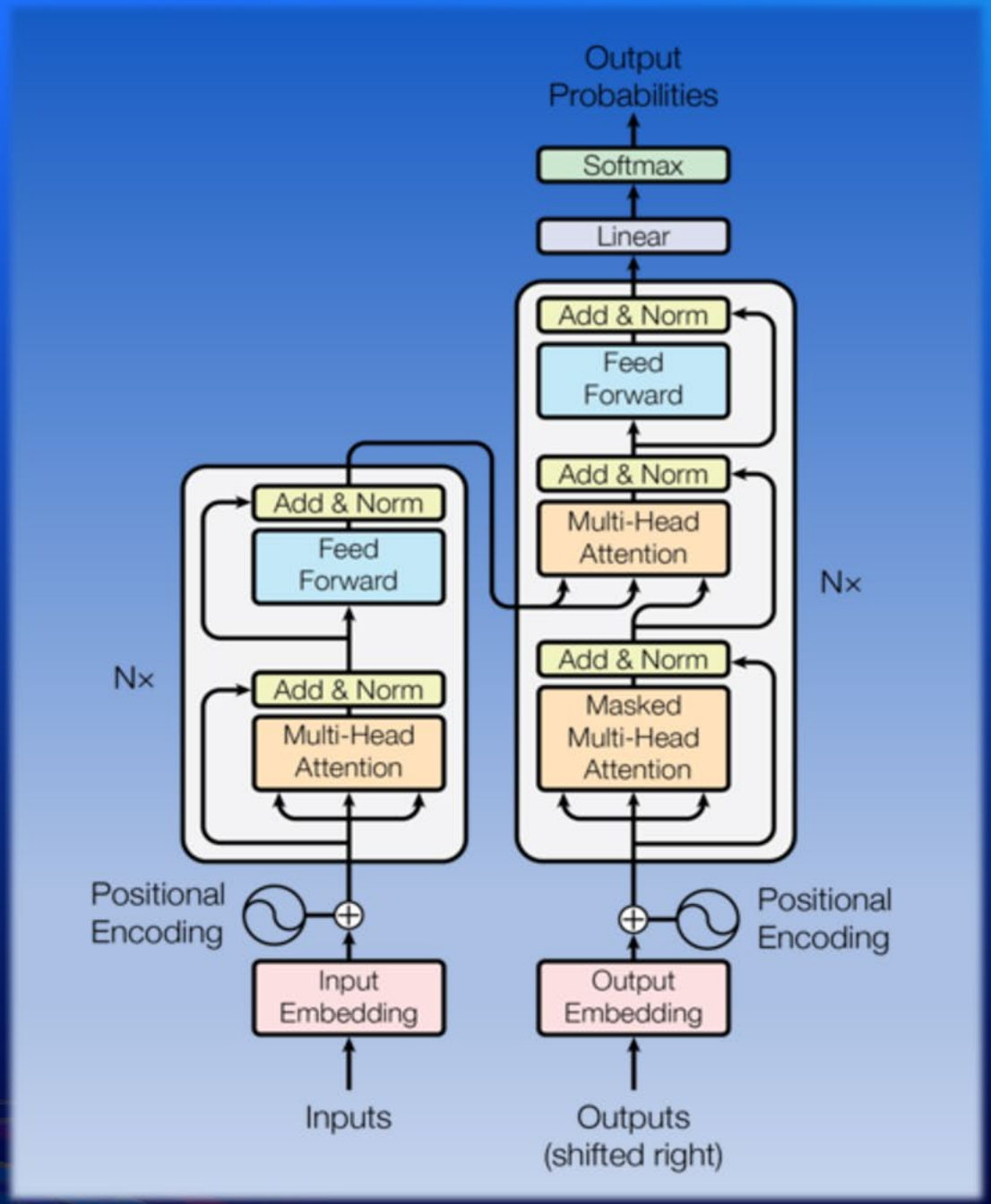
Layers in a transformer architecture

- Self-Attention Layer
  - Looks at other words in the sequence to form better encoding of word.
- Feed Forward Layer
  - Self-attention layer output are fed to a feed-forward neural network.
- Encoder-Decoder Attention Layer
  - Helps the decoder focus on relevant parts of the input sentence.

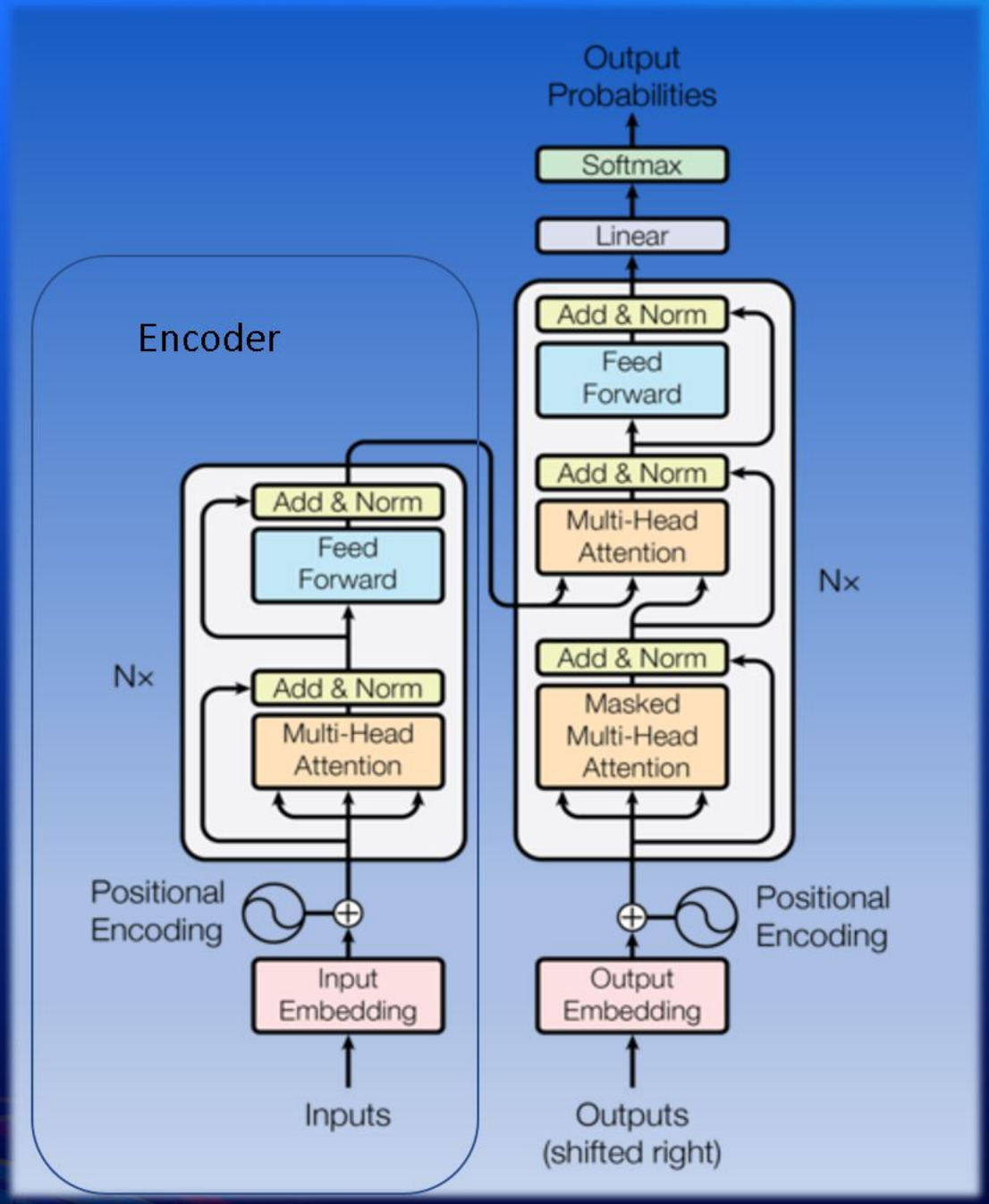
Relevant links

- Attention Is All You Need - https://arxiv.org/pdf/1706.03762.pdf
- BERT Paper - https://arxiv.org/pdf/1810.04805.pdf
- The Illustrated Transformer - http://jalammar.github.io/illustrated-transformer/

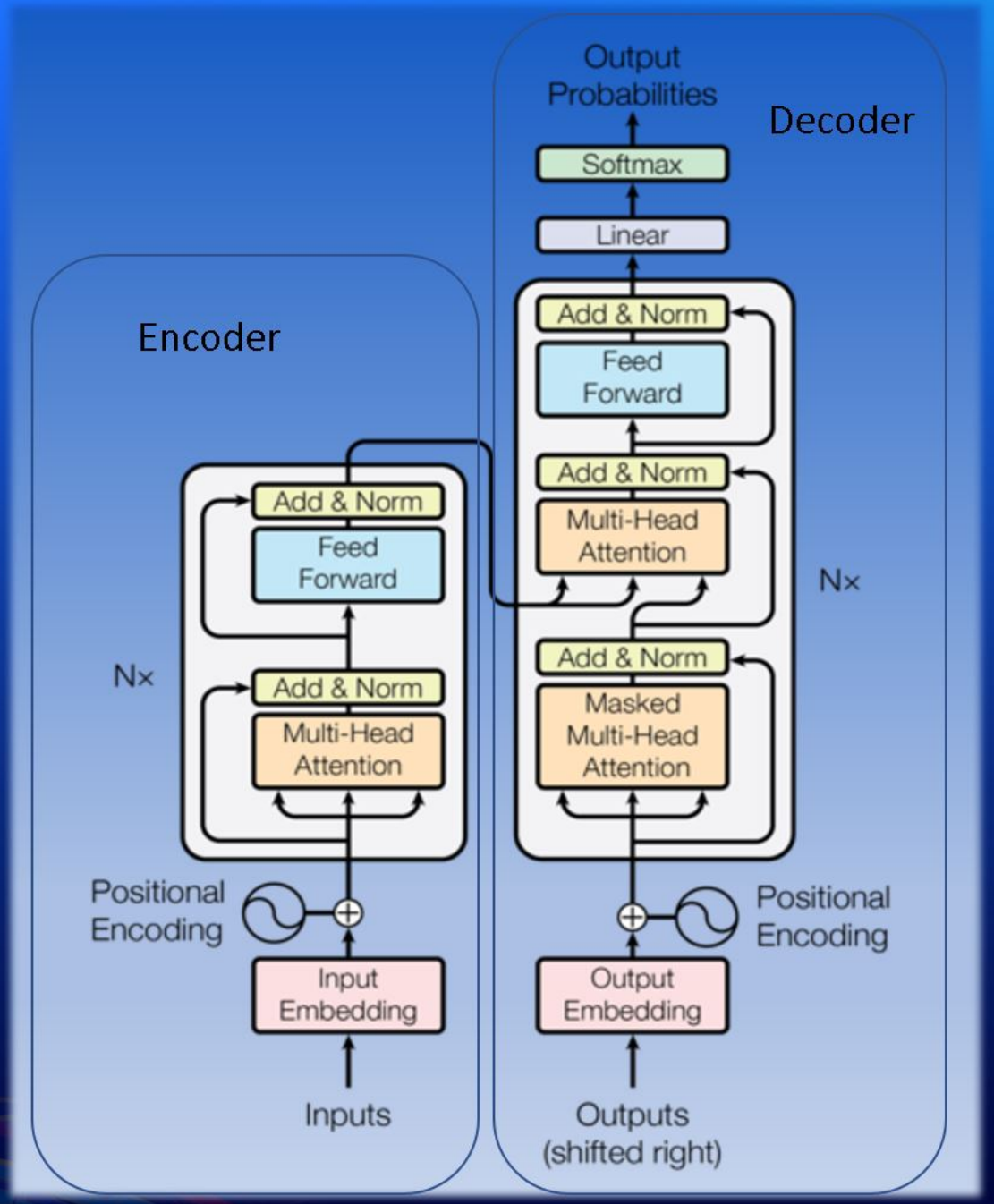




My | name | is | Akhil | . <BOS> | मेरा | नाम | अखिल | है | । | <EOS>



My | name | is | Akhil | . <BOS> | मेरा | नाम | अखिल | है | | | <EOS>



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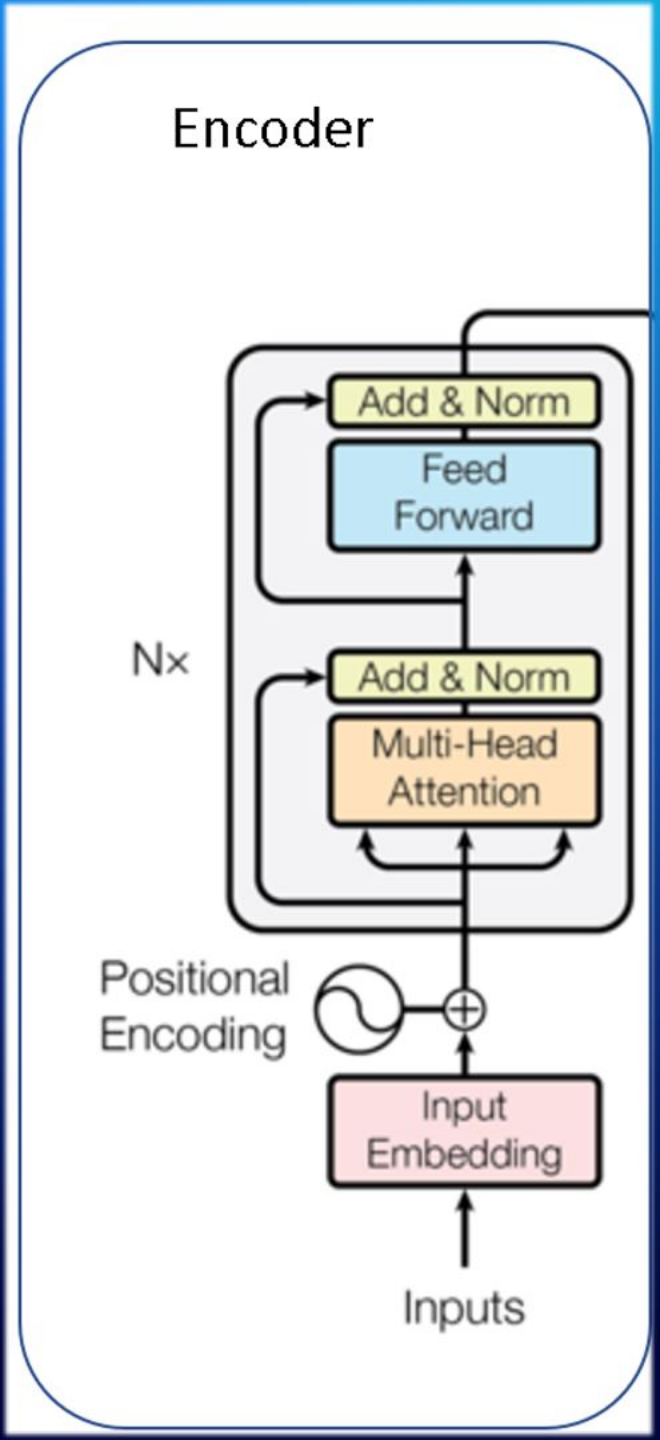
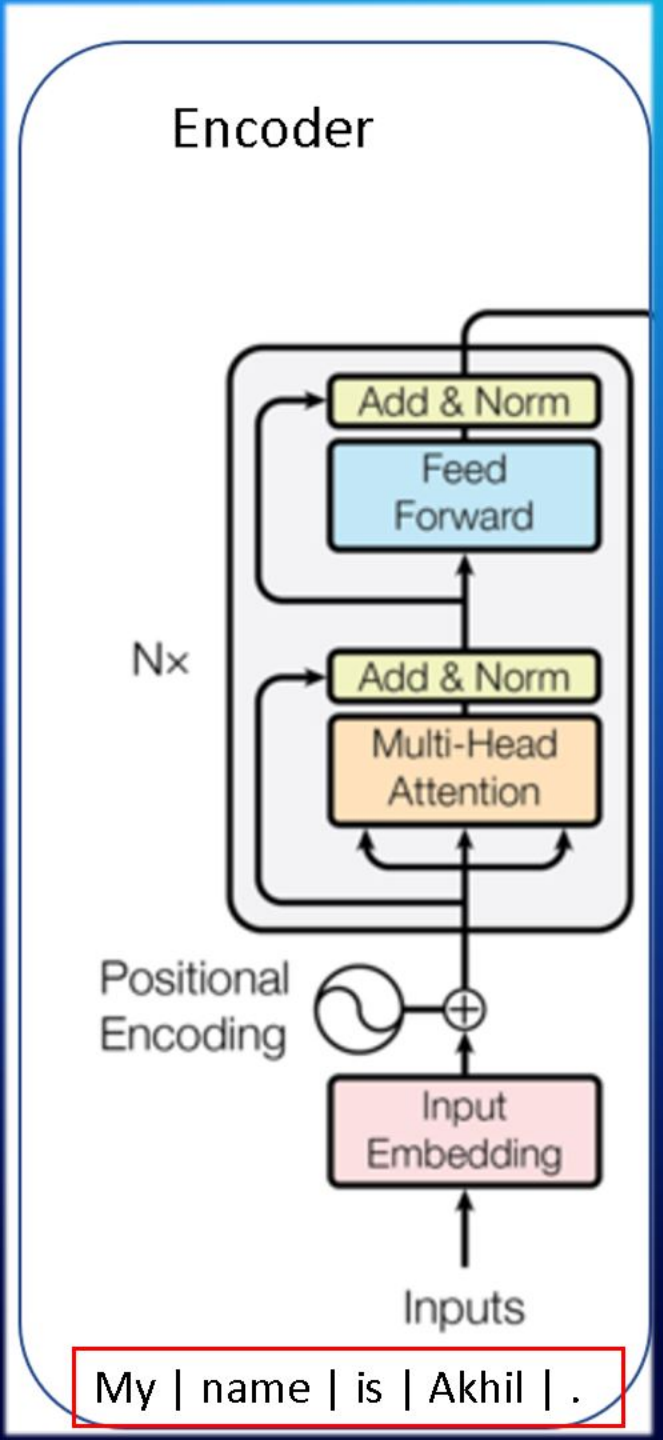

Encoder
Add & Norm
Feed Forward
Nx
Add & Norm
Multi-Head Attention
Positional Encoding
Input Embedding
Inputs


Encoder
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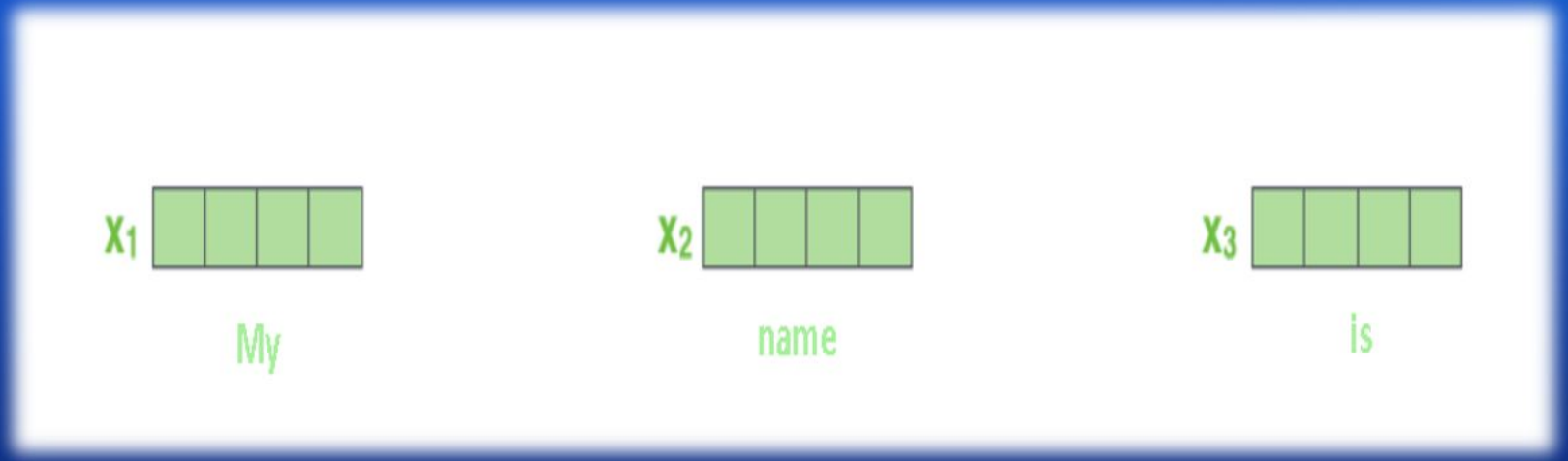
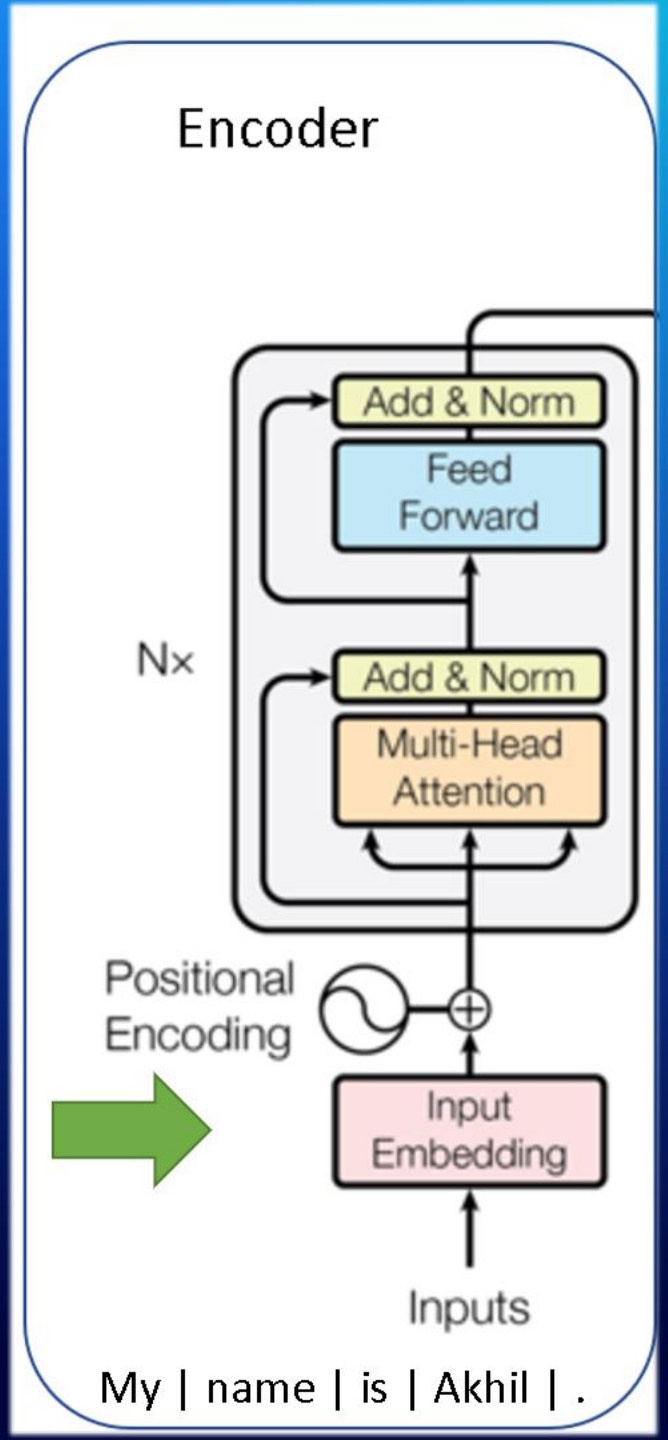
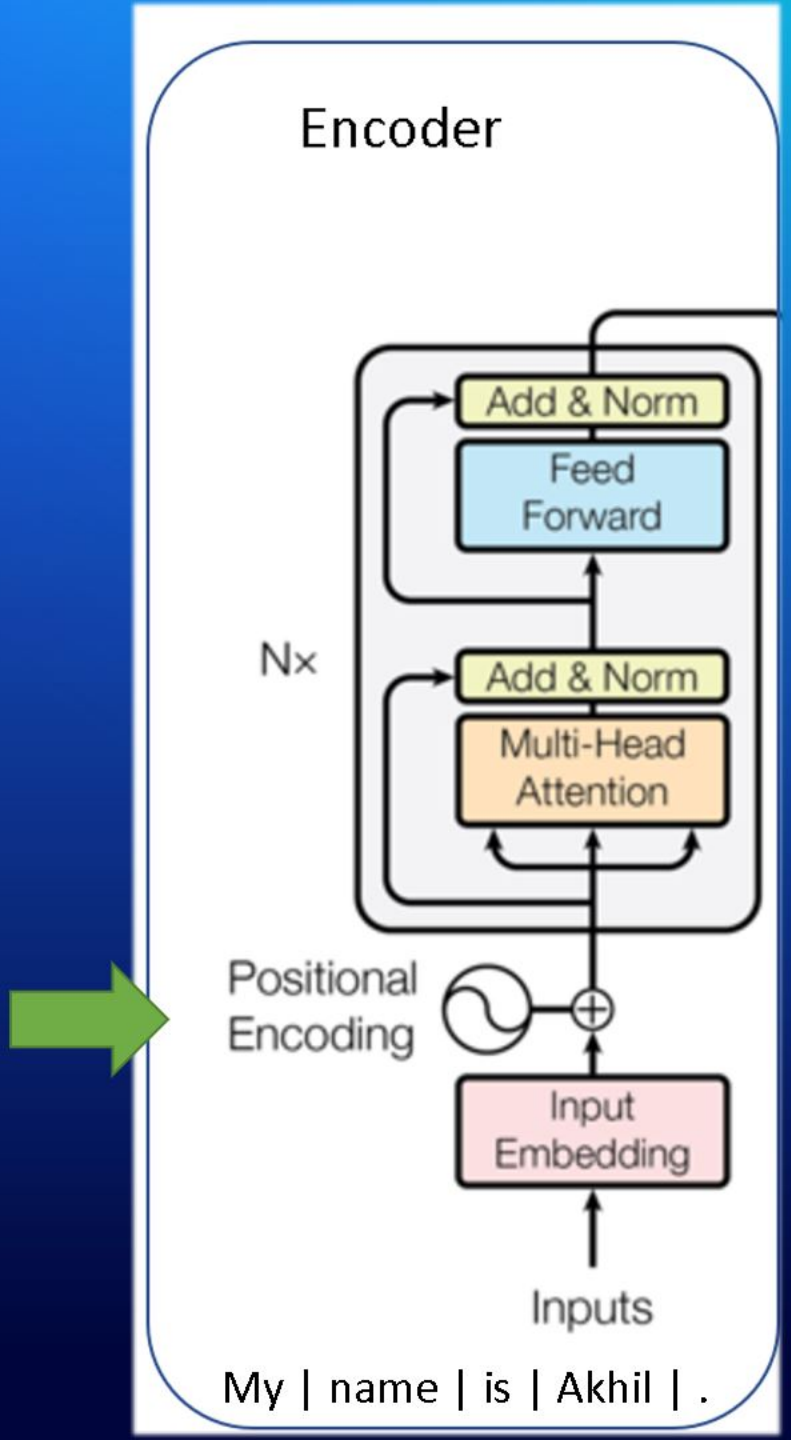
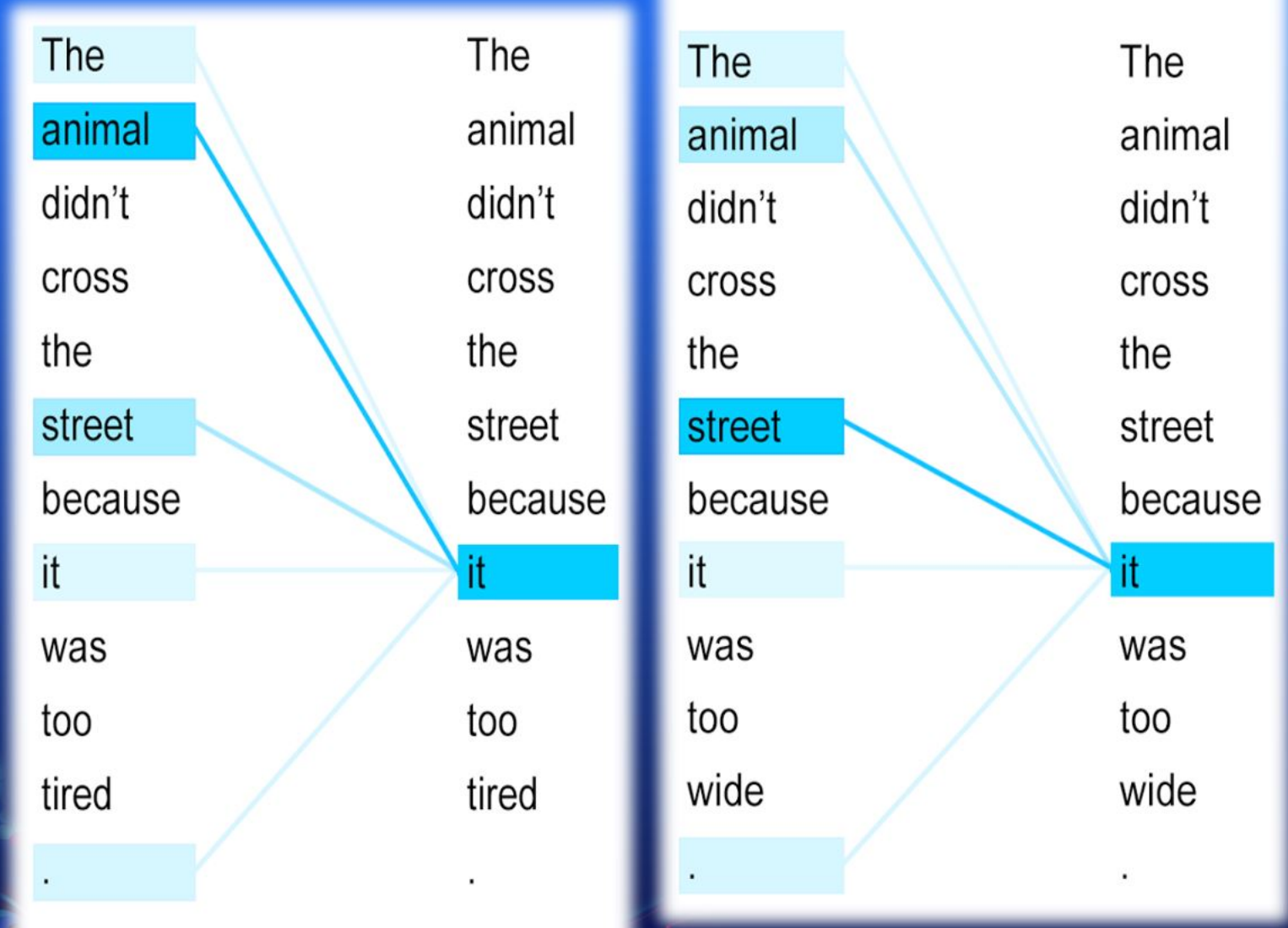
Feed Forward
Nx
Add & Norm
Multi-Head Attention
Positional Encoding
Input Embedding
Inputs
My | name | is | Akhil | .


x_1
x_2
x_3
My
name
is


Encoder
Add & Norm
Feed Forward
Add & Norm
Multi-Head Attention
N×
Positional Encoding
Input Embedding
Inputs
My | name | is | Akhil | .

Positional encoding lets us distinguish the words that occur at different positions within a sentence.




The
animal
didn't
cross
the
street
because
it
was
too
tired
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The
animal
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because
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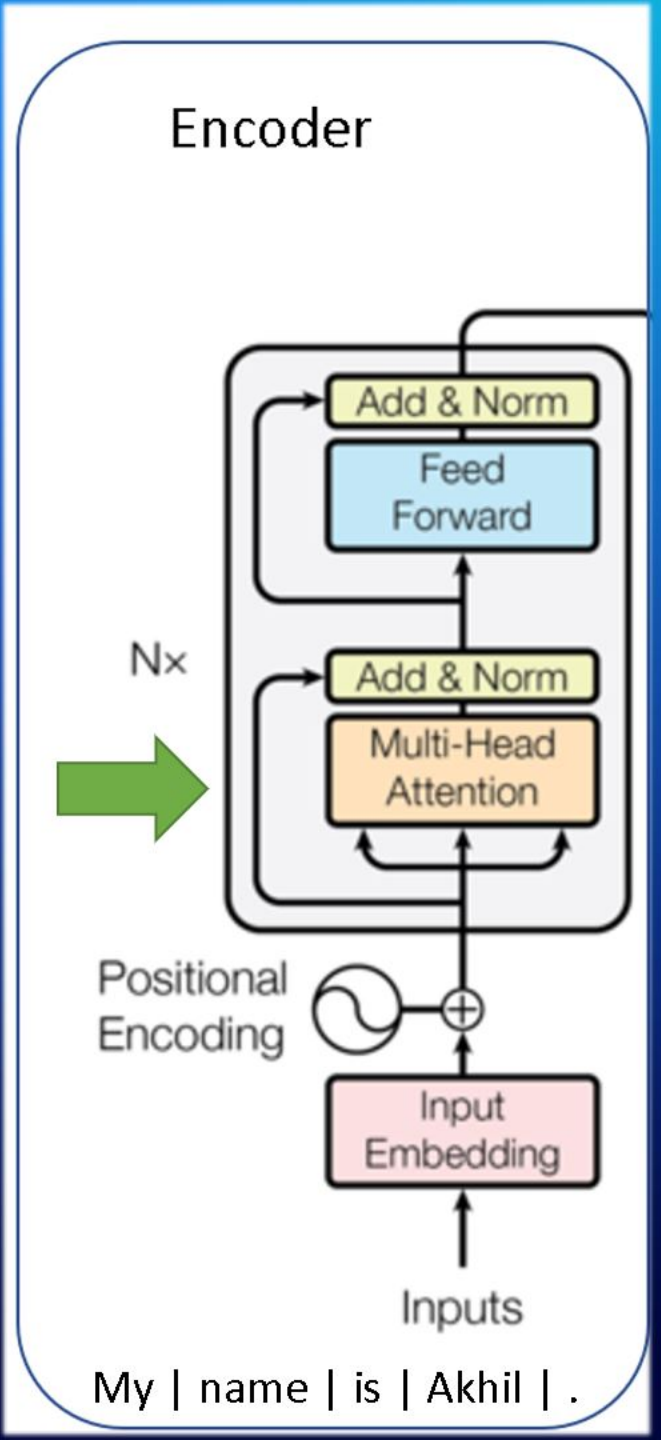
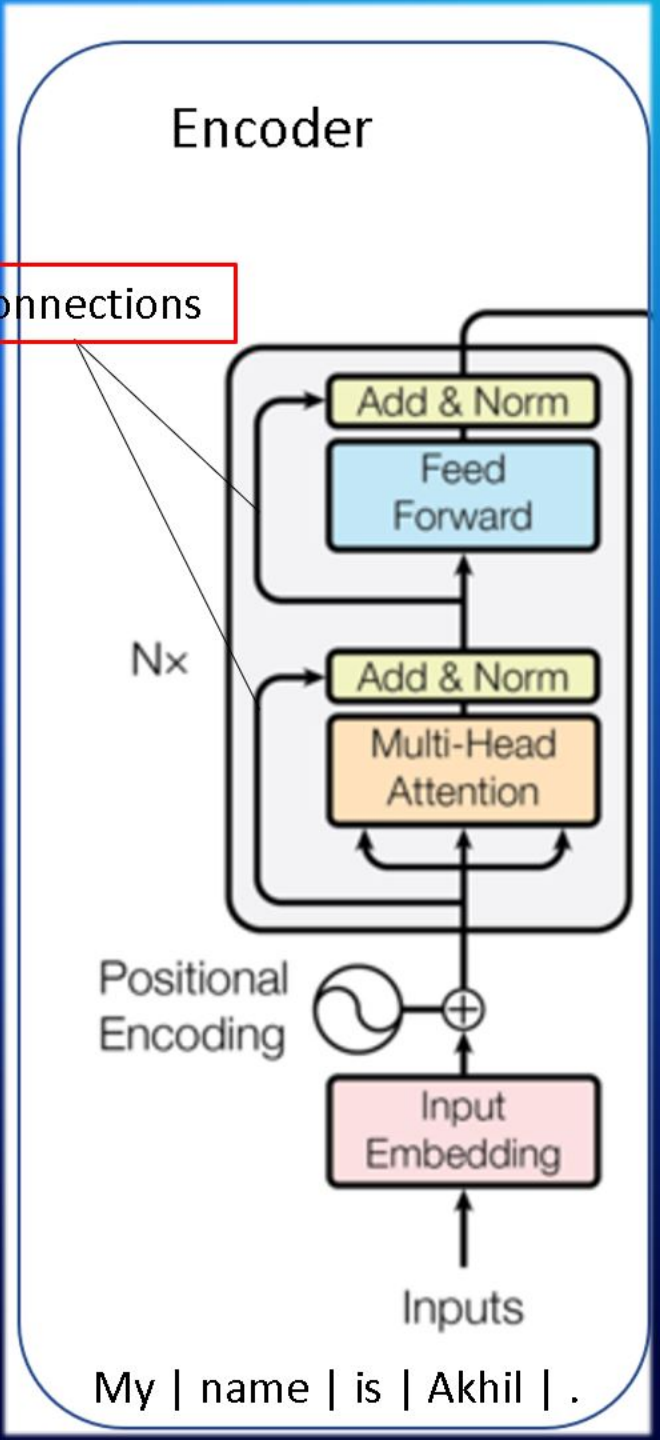
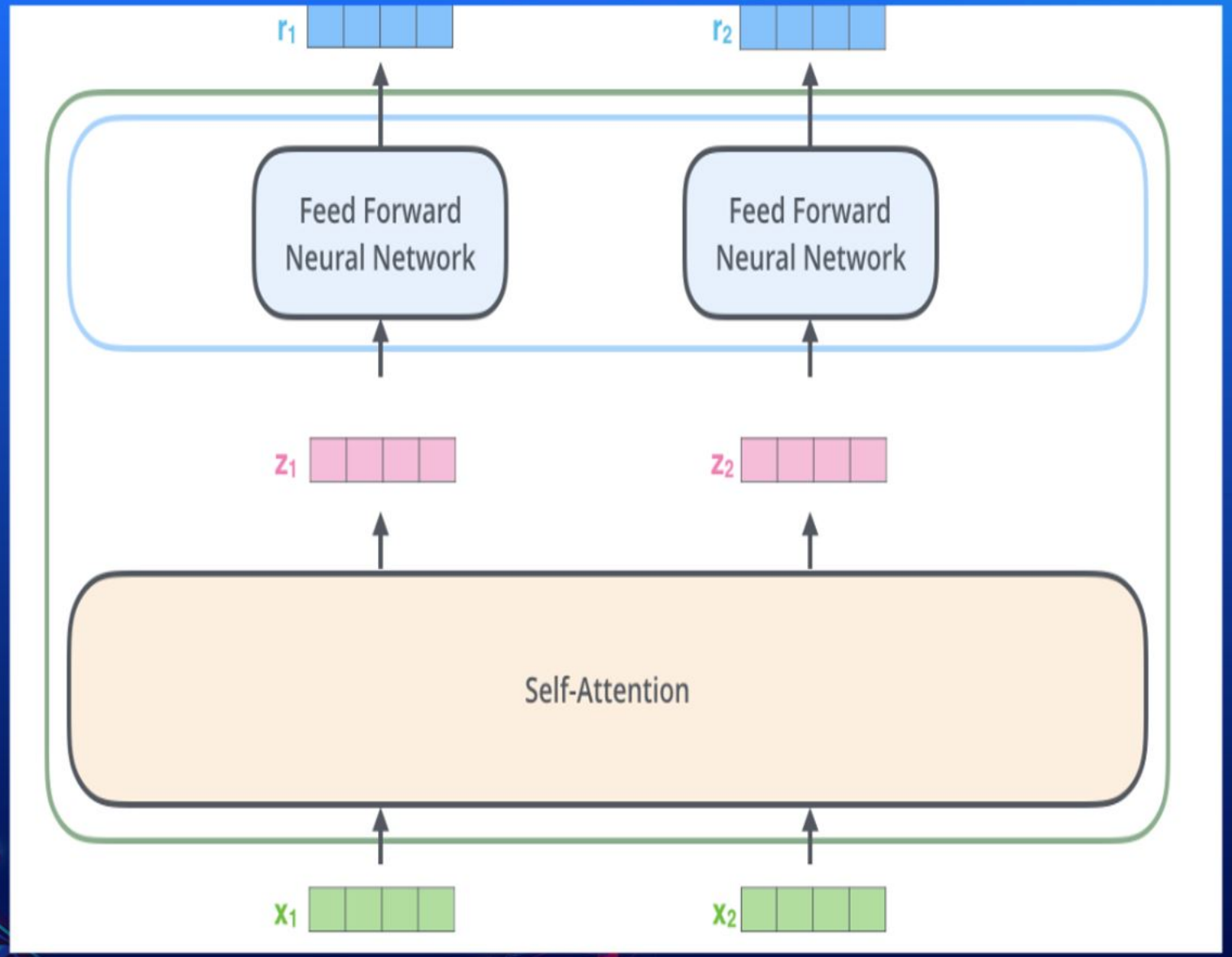
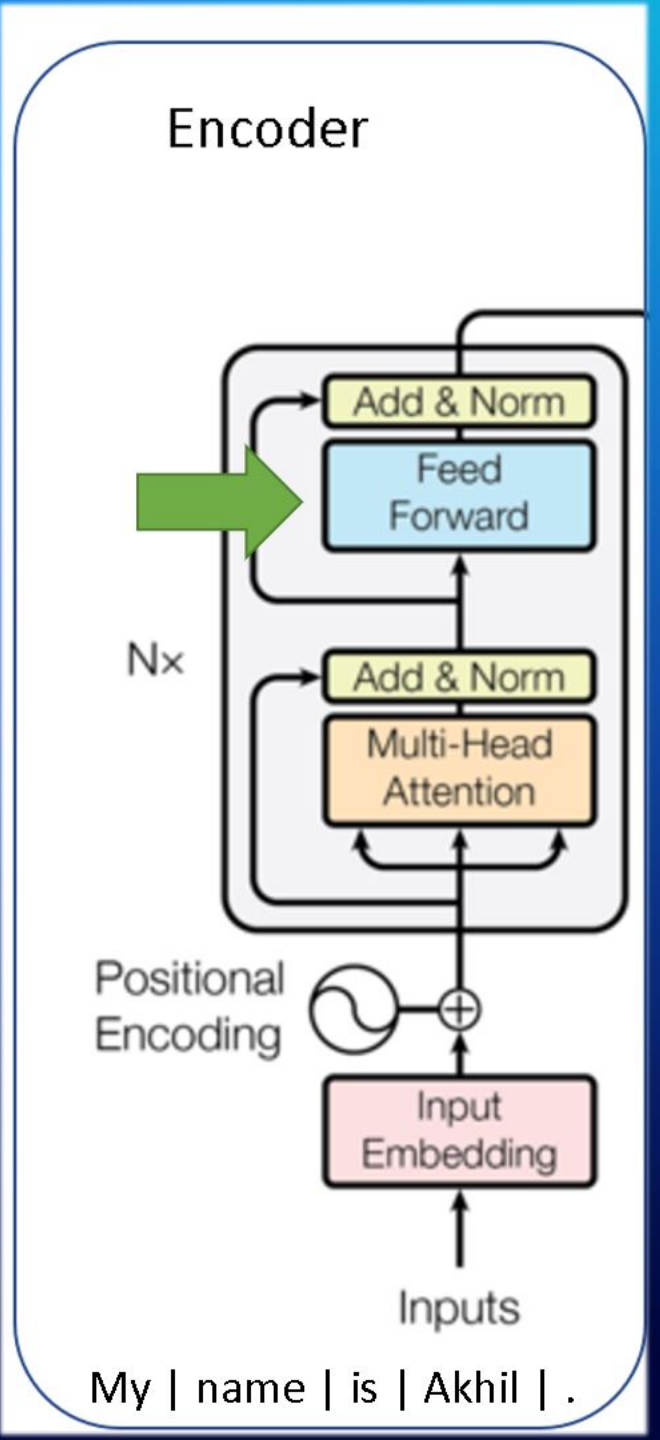

Encoder
Add & Norm
Feed Forward
Add & Norm
Multi-Head Attention
Nx
Positional Encoding
Input Embedding
Inputs
My | name | is | Akhil | .

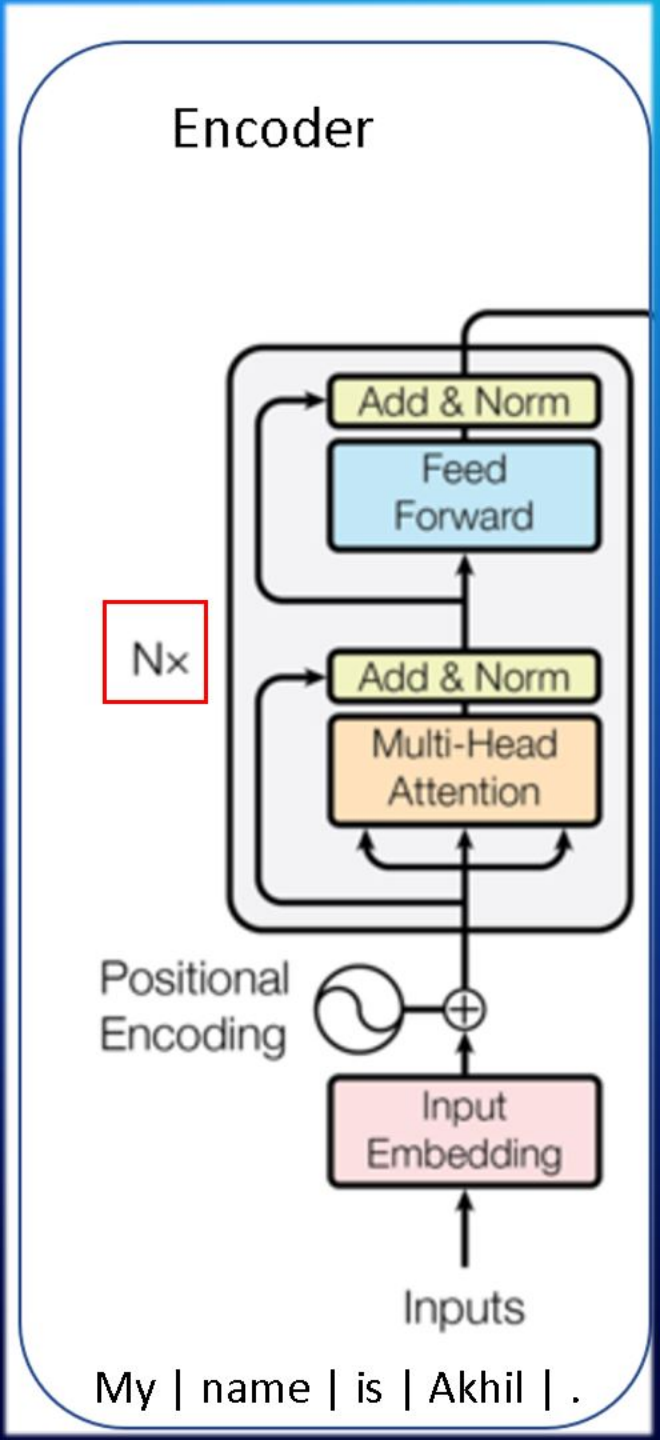
Residual connections help maintain the positional information across Layers and helps with better flow of gradients.



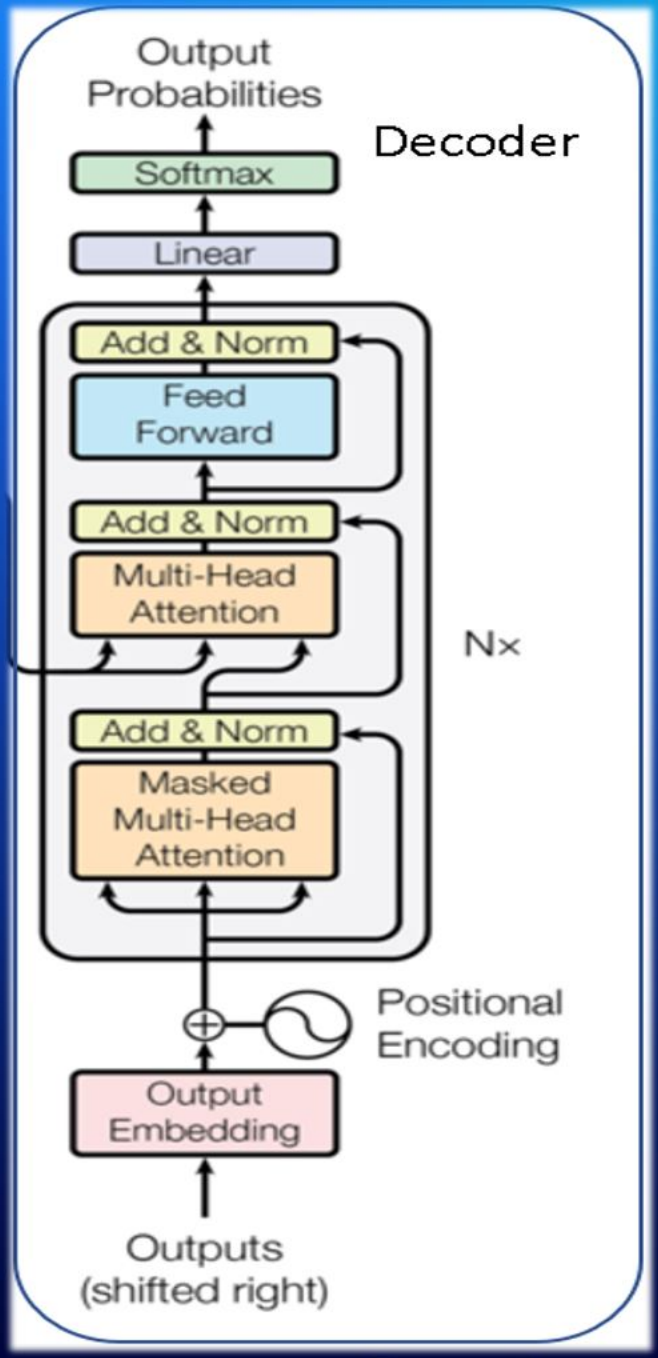

r1
r2
Feed Forward Neural Network
Feed Forward Neural Network
z1
z2
Self-Attention
x1
x2


Encoder
Add & Norm
Feed Forward
Nx
Add & Norm
Multi-Head Attention
Positional Encoding
Input Embedding
Inputs
My | name | is | Akhil | .

N encoder blocks are stacked to form the encoder. In the architecture proposed in the original paper, 6 blocks were stacked to form the encoder and the decoder.



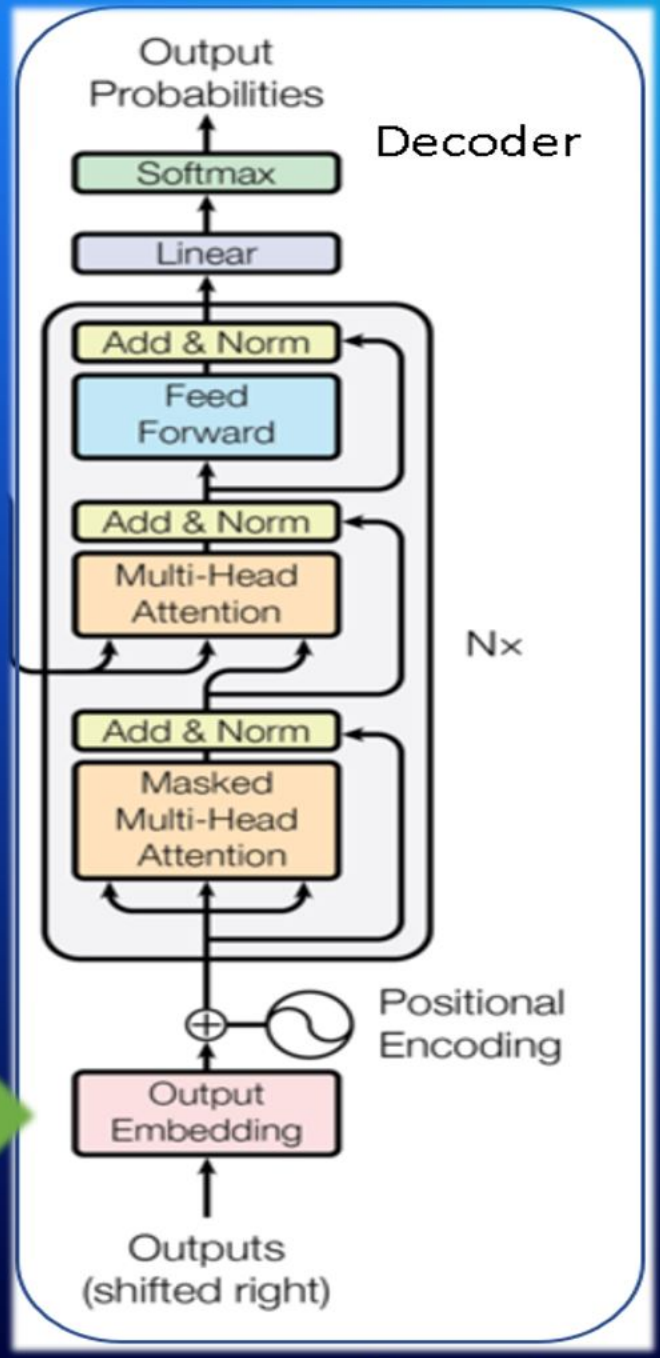
Decoder



<BOS> | मेरा | नाम | अखिल | है | । | <EOS>

Decoder

1. Output embedding



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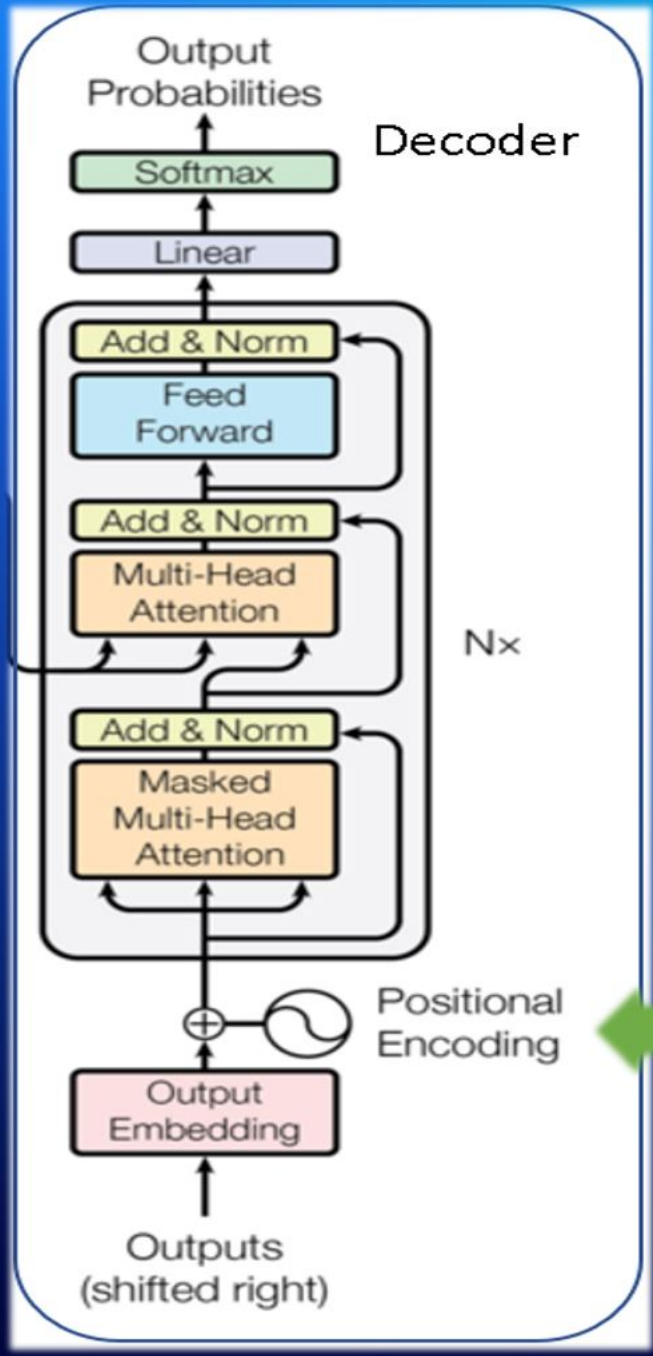
Decoder

1. Output embedding
2. Positional encoding



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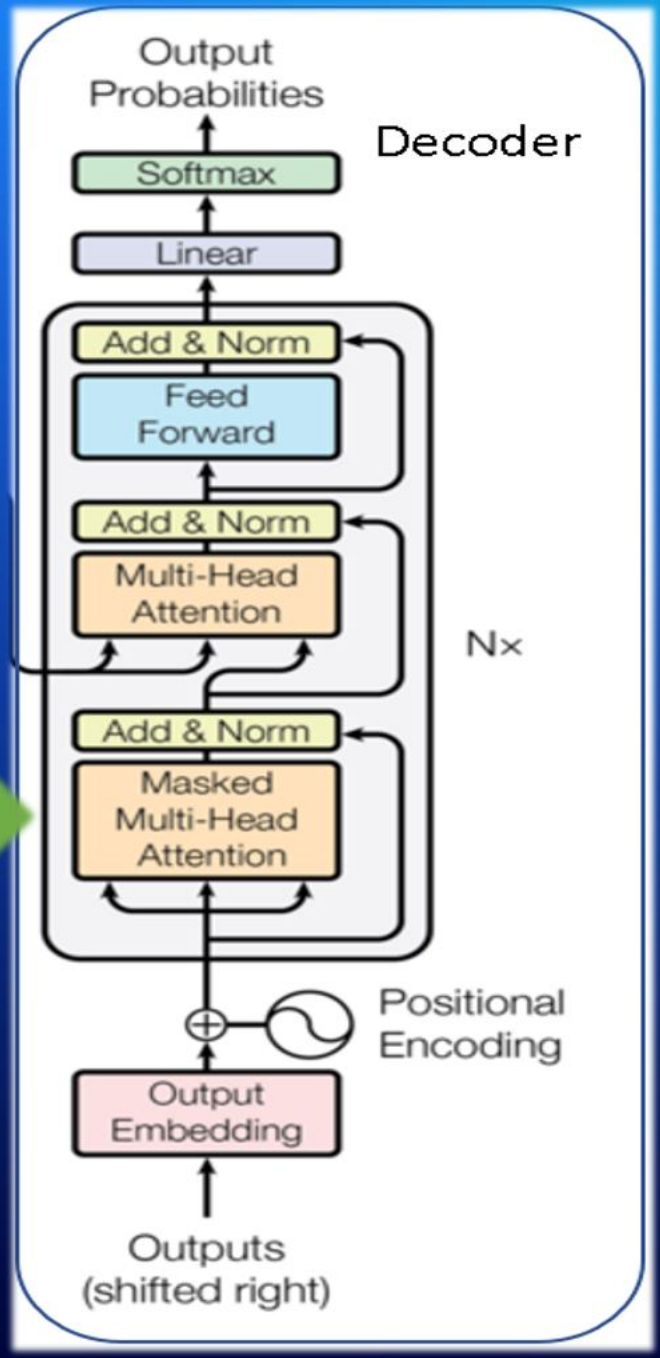
Decoder

1. Output embedding
2. Positional encoding
3. Masked attention



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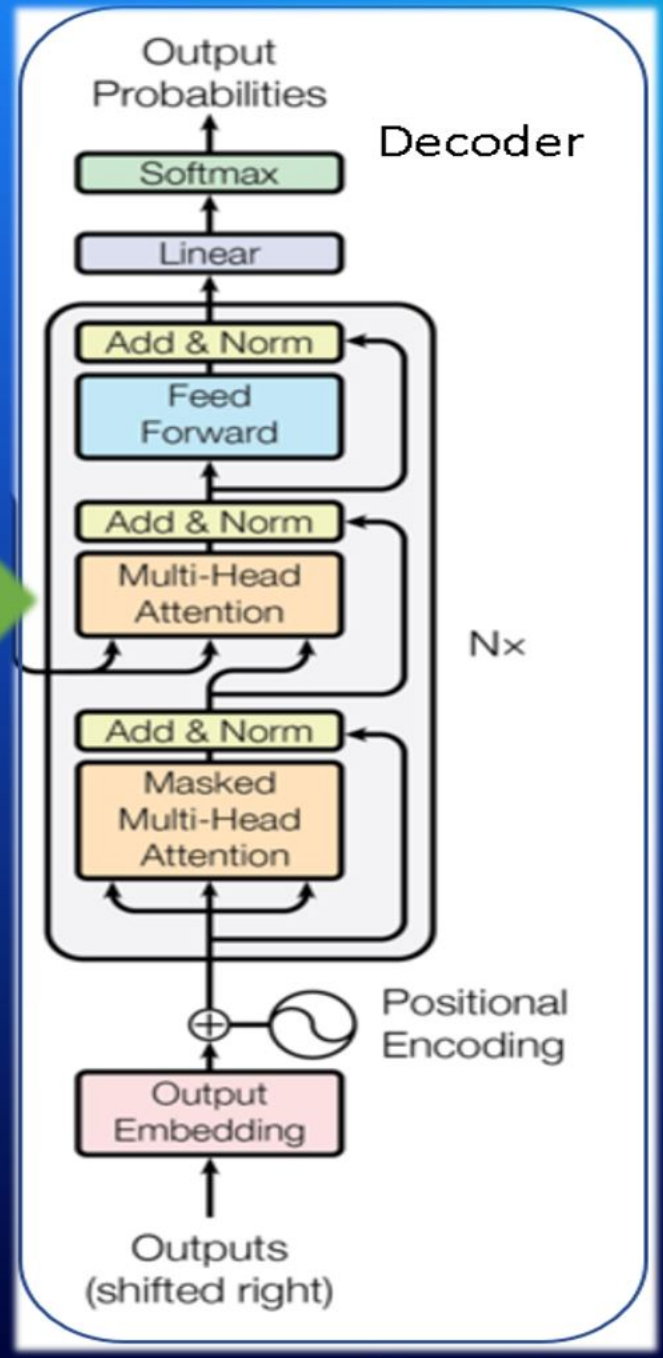
Decoder

1. Output embedding
2. Positional encoding
3. Masked attention
4. Encoder – Decoder attention



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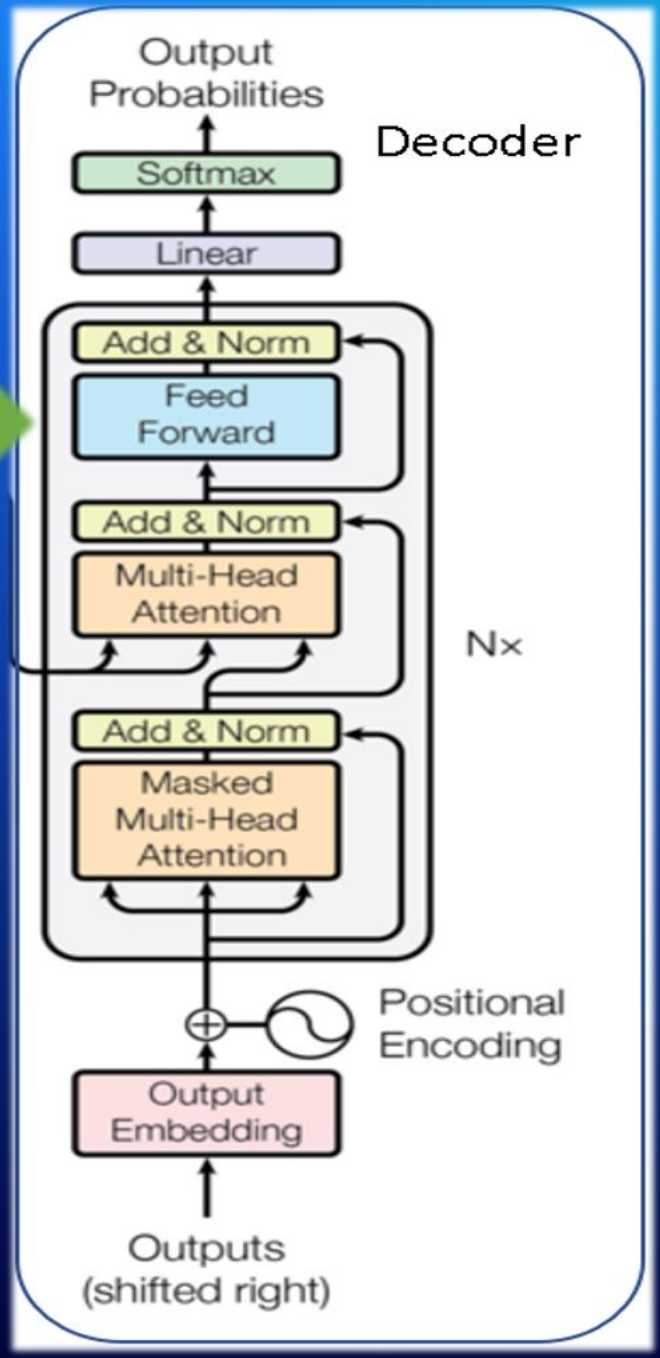
Decoder

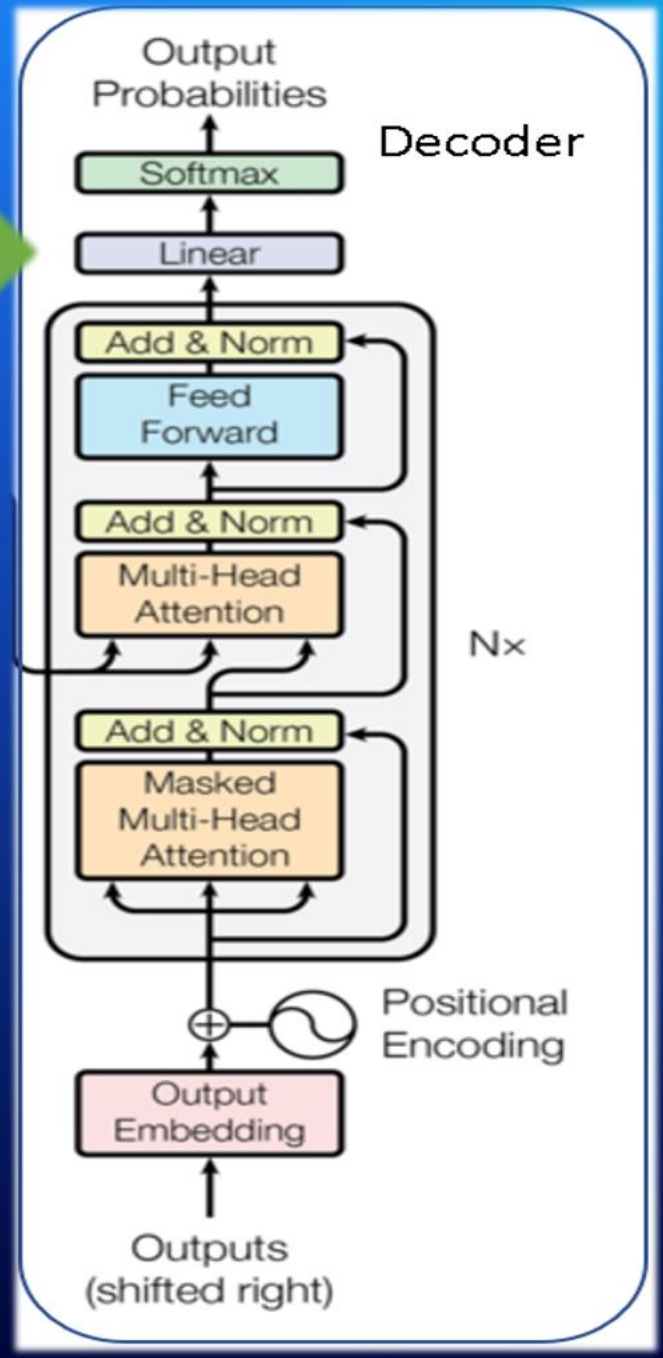
1. Output embedding
2. Positional encoding
3. Masked attention
4. Encoder – Decoder attention
5. Feed-forward layer



<BOS> | मेरा | नाम | अखिल | है | । | <EOS>

Decoder

1. Output embedding
2. Positional encoding
3. Masked attention
4. Encoder – Decoder attention
5. Feed-forward layer
6. Linear layer head



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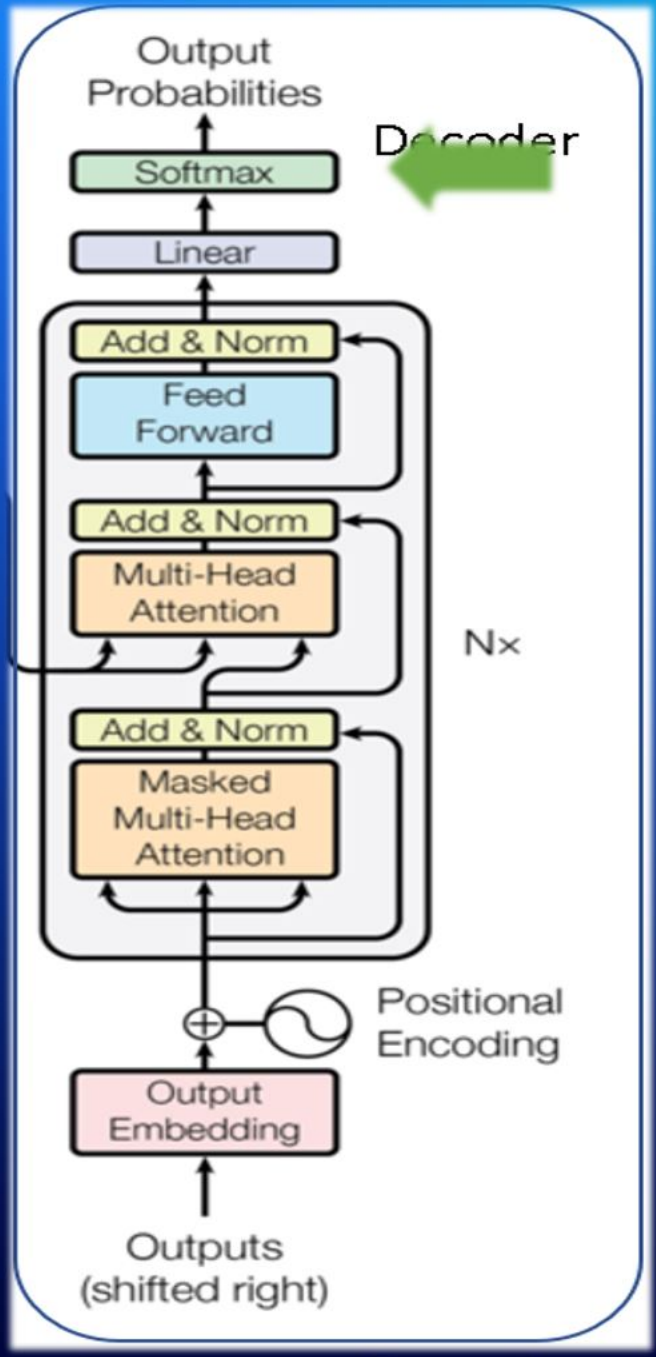
Decoder

1. Output embedding
2. Positional encoding
3. Masked attention
4. Encoder – Decoder attention
5. Feed-forward layer
6. Linear layer head
7. Softmax



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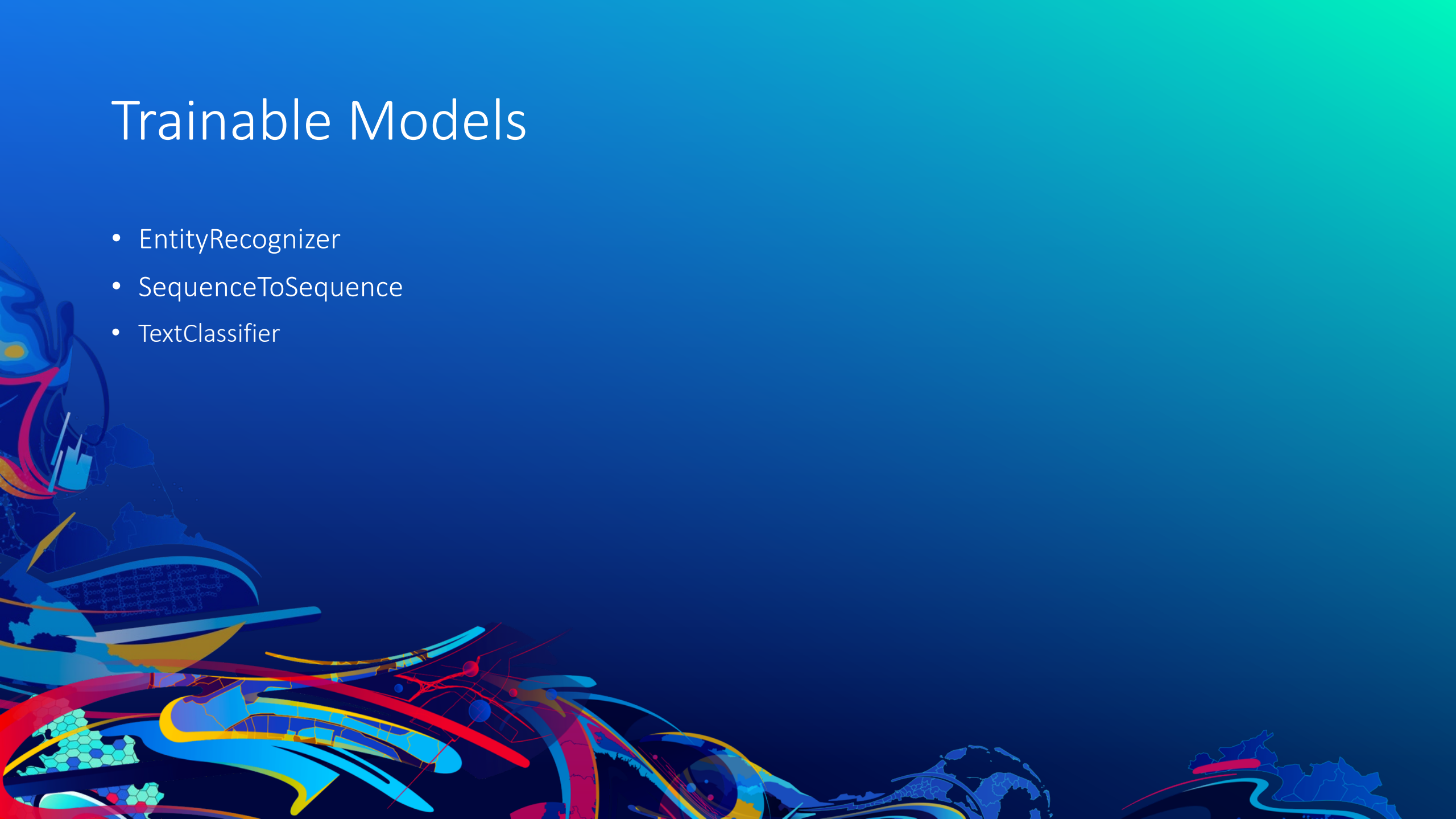
Trainable Models

- EntityRecognizer
- SequenceToSequence
- TextClassifier

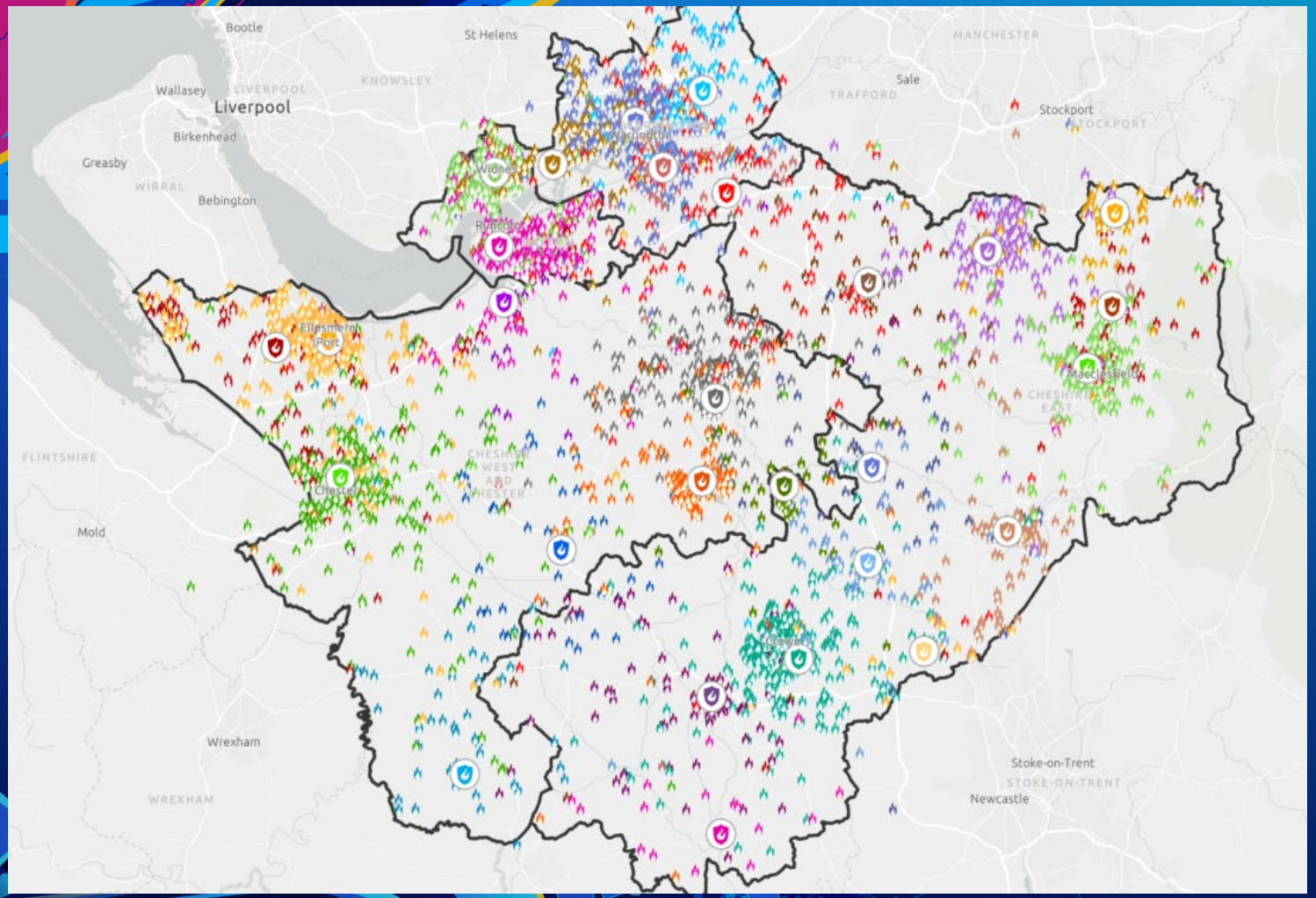


EntityRecognizer

Extract entities such as *"Organizations", "Person", "Date", "Country"*, etc. present in unstructured text.

Applications

- Street Address Extraction
- Extracting geographical entities such as **“city”, “state”, “country”** from unstructured text



Fire Report Analysis

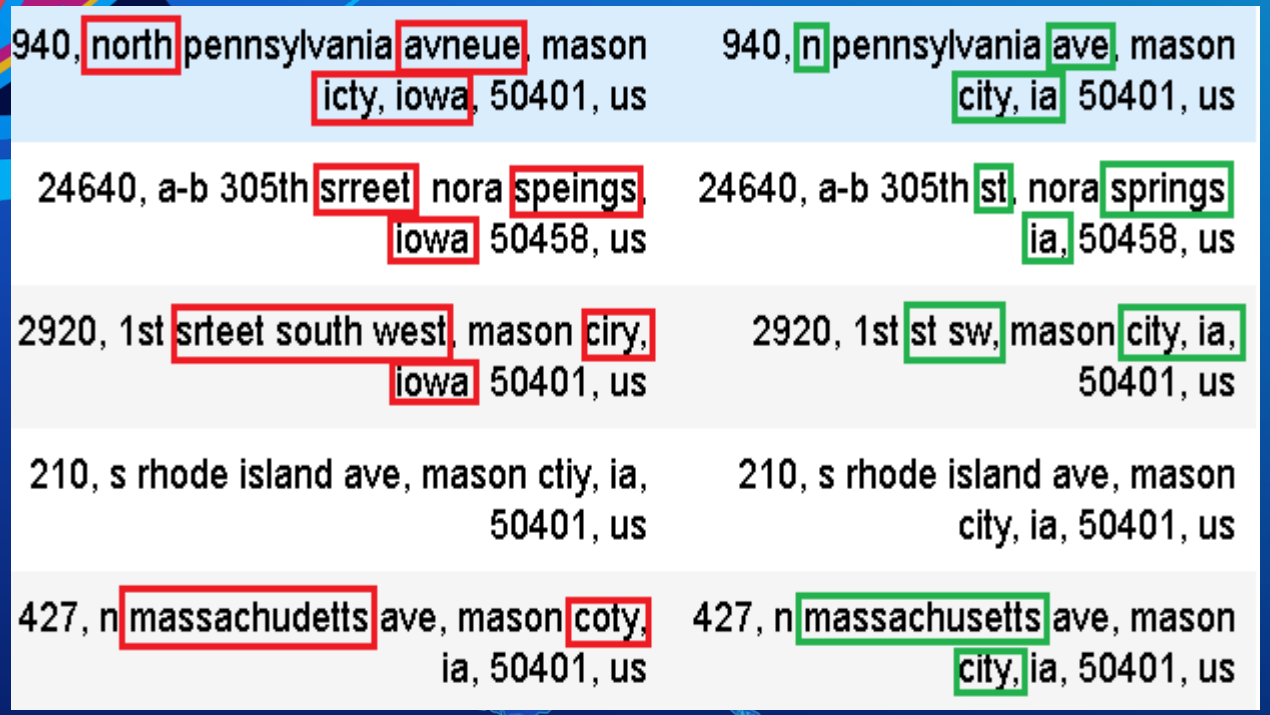
Akhil Negi

SequenceToSequence

Translate an input sequence to an output sequence of any length.

Applications

- Machine translation
- Text summarization
- Question Answering



940, north pennsylvania avneue, mason icty, iowa, 50401, us	940, n pennsylvania ave, mason city, ia 50401, us
24640, a-b 305th srreet nora speings, iowa 50458, us	24640, a-b 305th st, nora springs ia, 50458, us
2920, 1st srteet south west, mason ciry, iowa 50401, us	2920, 1st st sw, mason city, ia, 50401, us
210, s rhode island ave, mason ctiy, ia, 50401, us	210, s rhode island ave, mason city, ia, 50401, us
427, n massachudetts ave, mason coty, ia, 50401, us	427, n massachusetts ave, mason city, ia, 50401, us

Address standardization & correction

Akhil Negi

TextClassifier

Assigning tags/labels to unstructured text.

Text classification can be divided into 2 categories

- Single Label Text Classification
- Multi Label Text Classification

Applications

- Identifying country names from incomplete house addresses
- Tag inappropriate / toxic contents

comment_text	toxic	severe_toxic	obscene	threat	insult	identity_hate
an error regarding Stead's date as PCA of the year in Playfair. He was COY in 1972. ..AME Roberts was COY in 1974.	0	0	0	0	0	0
ad and carried out the edit myself. Thank you for letting me know. Please do provide an edit summary next time. Thank you again, and happy editing! 69.155.128.40	0	0	0	0	0	0
"" You could stand to be more informative and less hostile in your edit comments. The comment ""rmv crap"" implied to me that you were removing vandalism, not a good-faith edit to the article (the ""spoiler"" warning added by "" "	1	0	0	0	0	0
apology I hereby make a public apology to User:Docku for this comment. I sincerely regret the genuine hurt and pain it caused to you, and I shall do my best to refrain from making similar comments in future	0	0	0	0	0	0
l pluggers, now that's a cute one. You want to talk snake-oil? In what world do you pump a body full of chemotheraphy, hoping to poison the cancer out of a human body? You're an uneducated bigot. ıcognitive.com/files/Top%20Japanese%20Surgeon%20Uses%20Gerson%20Therapy,%20Publishes%20Research.pdf	0	0	0	0	0	0

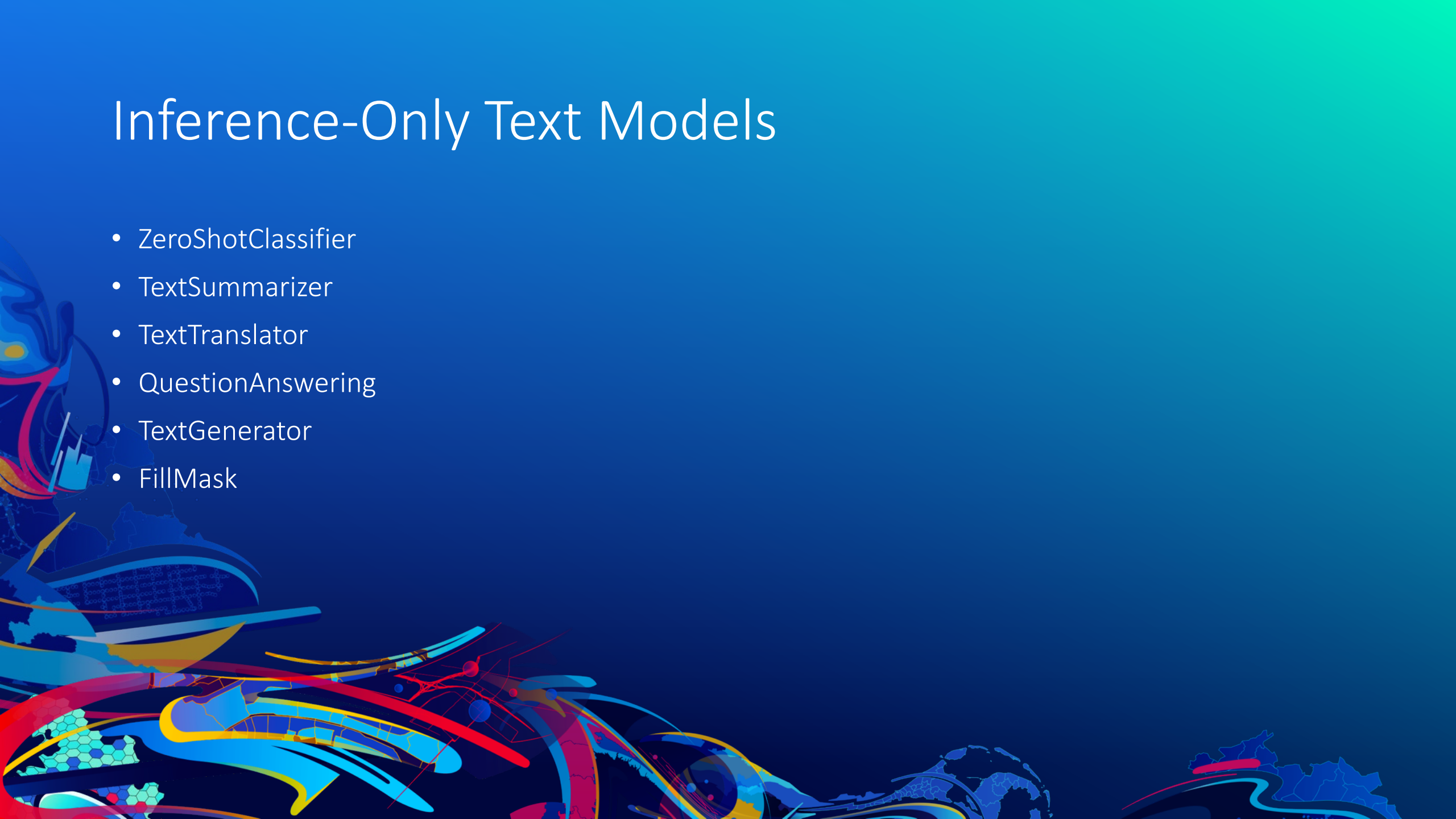
2120, POCURO, ESTACIONAMIENTO 309, PROVIDENCIA, METROPOLITANA DE SANTIAGO	CL	1.000000
2681, MOSCONI GENERAL AV.	AR	1.000000
237, 백제고분로19길	KR	1.000000
2461, BONNY DR, COCOA, BREVARD, FL, 32926	US	1.000000
37, Schiefer, 8350	AT	0.997607
29, LATHAM STREET, YARRABILBA, QLD, 4207	AU	1.000000
118a, Hauptstraße, 8740	AT	1.000000
13A, BO LLANO, 39409	ES	1.000000
131, Поддубного, БОСТАНДЫКСКИЙ РАЙОН, АЛМАТЫ	KZ	1.000000
SN, CALLE 37, CIUDAD DEL CARMEN, Carmen, Campeche	MX	1.000000
12, Kościelna, Gołubie, kartuski, pomorskie, 83-316	PL	1.000000
12, Werfelstraße, 1170	AT	1.000000
7, SCOTT STREET, MOUNT HOPE, NSW, 2877	AU	1.000000
5422, GROUSSAC, PAUL	AR	0.999999
17, Morelvej, 8920	DK	1.000000
２１２號, 三興路東勢段, 平鎮市, 東勢里	TW	1.000000
48, Częstochowska, Czarny Las, częstochowski, śląskie, 42-233	PL	1.000000
92H, Moste, Moste, Komenda, Osrednjeslovenska, 1218	SI	1.000000
5551, ECHEANDIA	AR	0.999999
16, Rue de la Republique, Amilly, 28300	FR	1.000000
６號, 東森路５５巷, 楊梅市, 永寧里	TW	1.000000
4A, Serupvej, 8600	DK	1.000000
62, 18 DE JULIO (VILLA GUADALUPE), 15562	UY	1.000000
1-3, HERNER PLACE, NORTH GEELONG, VIC, 3215	AU	1.000000

Identifying Country Names from Incomplete House Addresses

Anurag Sharma

Inference-Only Text Models

- ZeroShotClassifier
- TextSummarizer
- TextTranslator
- QuestionAnswering
- TextGenerator
- FillMask



ZeroShotClassifier

Classifies an input sequence from a list of candidate labels.

Based on **Zero-Shot Learning**

- Aims classify data based on very few or even no training example.

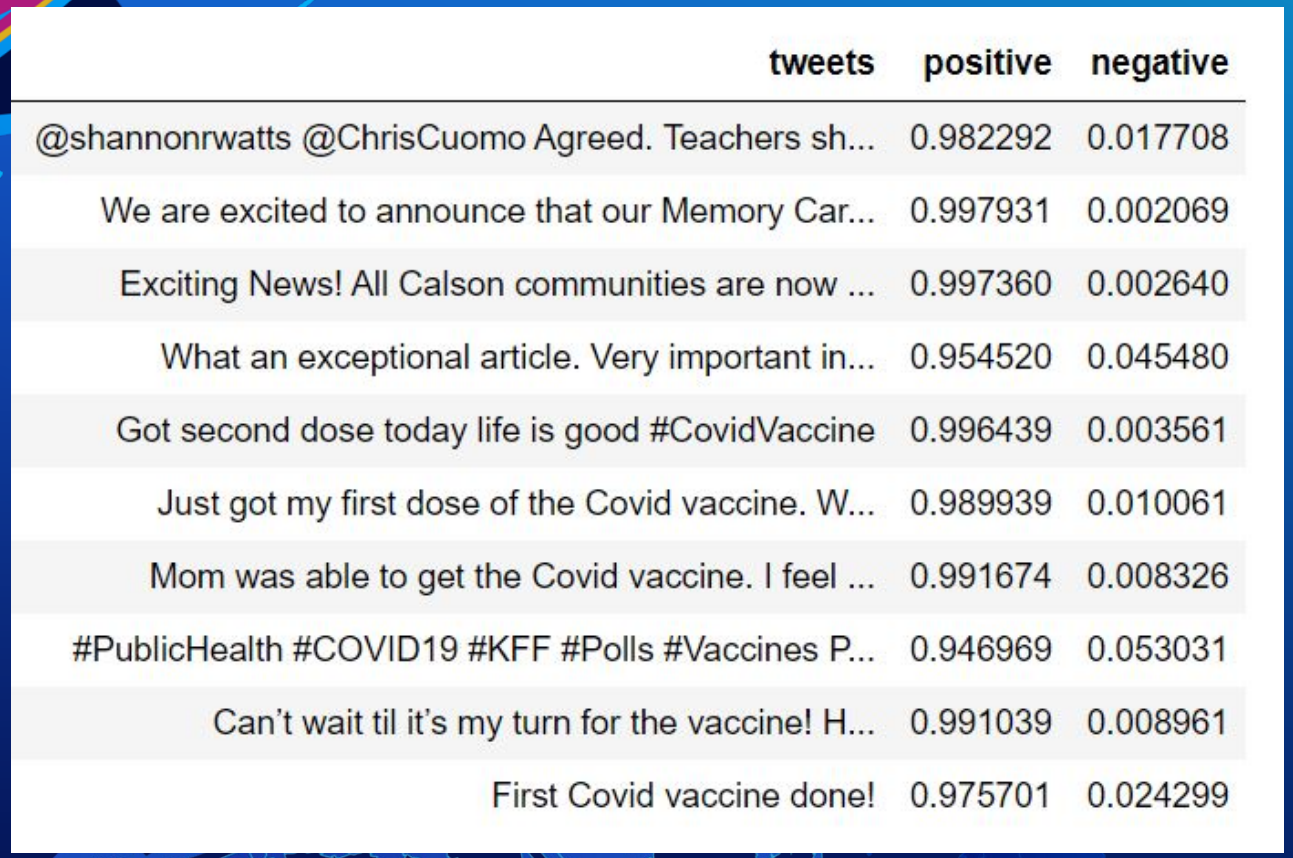
Applications

- Classify text with no training examples

```
sequence = "Who are you voting for in 2020?"
candidate_labels = ["politics", "public health", "economics"]

classifier.predict(sequence, candidate_labels)
```

```
[{'sequence': 'Who are you voting for in 2020?',
  'labels': ['politics', 'economics', 'public health'],
  'scores': [0.972518801689148, 0.014584126882255077, 0.012897057458758354]}]
```



tweets	positive	negative
@shannonrwatts @ChrisCuomo Agreed. Teachers sh...	0.982292	0.017708
We are excited to announce that our Memory Car...	0.997931	0.002069
Exciting News! All Calson communities are now ...	0.997360	0.002640
What an exceptional article. Very important in...	0.954520	0.045480
Got second dose today life is good #CovidVaccine	0.996439	0.003561
Just got my first dose of the Covid vaccine. W...	0.989939	0.010061
Mom was able to get the Covid vaccine. I feel ...	0.991674	0.008326
#PublicHealth #COVID19 #KFF #Polls #Vaccines P...	0.946969	0.053031
Can't wait til it's my turn for the vaccine! H...	0.991039	0.008961
First Covid vaccine done!	0.975701	0.024299

ZeroShotClassifier & Vaccine Hesitancy

Anurag Sharma

TextSummarizer

Text summarization - technique of shortening long pieces of text.

Create a coherent & concise output keeping only the main points of the input sentence.

Applications

- Generate summary for a given text

Generate Summaries for ArcGIS Items

Anurag Sharma

TextTranslator

Machine translation is a sub-field of computational linguistics

- Deals with the problem of translating an input text from one language to another

Fine-tuned on a machine translation task.

Applications

- Translation of text from one language to another.

Relevant links

- Visualizing A Neural Machine Translation Model - https://jalammar.github.io/visualizing-neural-machine-translation-mechanics-of-seq2seq-models-with-attention/

Healthy Streets

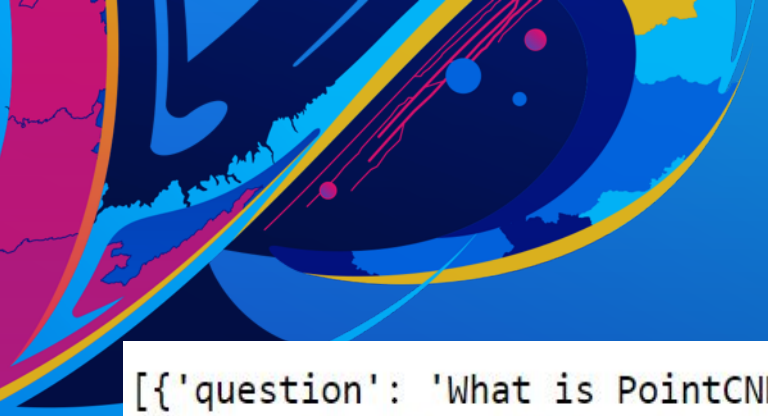
Currently, one travel lane is coned off on South Pleasant Valley Road for walking and biking as part of the City of Austin's **Healthy Streets** initiative during the COVID-19 pandemic to accommodate increased trail traffic and to support social distancing. **This initiative is not related to this project.**

Translating ArcGIS StoryMap from one language to another

Anurag Sharma

Other Inference-Only Text Models

- QuestionAnswering
  - Based on **extractive question answering** mechanism
  - When presented with a question and a passage:
    - Returns the string sequence from the passage which answers the question.
- TextGenerator
  - Generate sequence of text for a given incomplete text sequence or paragraph.
  - Can be used for text autocorrection, assists writers/authors in autocompleting sentences
- FillMask
  - Used to provide suggestion for a missing token/word in a sentence.



```
[{'question': 'What is PointCNN?',
  'answer': 'to efficiently classify and segment points
  'score': 0.43700891733169556},
 {'question': 'How is Point cloud dataset collected?',
  'answer': 'Lidar sensors',
  'score': 0.3490387797355652},
 {'question': 'What is Lidar?',
  'answer': 'light detection and ranging',
  'score': 0.8532344102859497}]
```

QuestionAnswering, TextGenerator & FillMask model Demos

Anurag Sharma

Summary

- Often, spatial data is hidden away in an unstructured format.
- **Natural language processing** (NLP) is a field of computer science that
  - Deals with the interactions between computers and human language.
  - Can be used to extract GIS and/or spatial information from unstructured text
- In this session, we learnt
  - How GIS and NLP came together through the *arcgis.learn.text* submodule in ArcGIS API for Python.
- We have demonstrated the use of
  - **EntityRecognizer** model to extract entities from unstructured text.
  - **SequenceToSequence** model to regularize and correct street address.
  - **TextClassifier** model to identify country names from incomplete house addresses
  - **Inference-Only Text models** to perform machine translation, summarization, question answering

Resources to learn more

- **Install Deep Learning dependencies** - https://developers.arcgis.com/python/guide/install-and-set-up/#Install-deep-learning-dependencies
- **Unstructured Text Models documentation** - https://developers.arcgis.com/python/api-reference/arcgis.learn.toc.html#unstructured-text-models
- Geospatial deep learning with *arcgis.learn*
  - Guides - https://developers.arcgis.com/python/guide/geospatial-deep-learning/
  - Samples - https://developers.arcgis.com/python/sample-notebooks/
- Queries & Issues
  - **GeoNet, The ESRI Community** - https://community.esri.com/
  - **ArcGIS API for Python GitHub** - https://github.com/Esri/arcgis-python-api

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