DSP301-AIML-2025-26-M

Dr. Rajesh Kumar Mundotiya
TAs: Nabanita, Shankar and Saurabh

Indian Institute of Technology (IIT) Bhilai / 2025-26

July 31, 2025

Outline

1. Introduction
2. Content
3. Conclusion

Schedule

Time and Venue

- **Time:** Thursday (2:30 PM – 5:30 PM)
- **Venue:** ED1 105 (Lab)

About Course

Areas Covered

- Language Translation (Text Processing)
- Voice Identification or Text to Voice (Audio-Speech Processing)
- Computer Vision (Segmentation and Classification)
- Reinforcement Learning
- Game Development
- Hardware Deployment

Course Objectives

- Provide hands-on experience in various AI/ML techniques
- Develop practical skills in implementing AI/ML solutions
- Enable students to work on real-world AI/ML projects

Grading Schema

Table 1: Grading Scheme

Score (%)	**Grade**
100% to 94%	A+
<94% to 85%	A
<85% to 75%	A-
<75% to 65%	B
<65% to 55%	B-
<55% to 45%	C
<45% to 35%	C-
<35% to 30%	D
<30% to 0%	F

About the Course - Content

Evaluation Phases

1. Research
2. Implementation
3. Deployment/Validation

Content

- Text Processing
- Speech Processing
- Computer Vision
- Game Playing
- AI/ML Development Boards/Kits/Drones

About the Course - Syllabus

Syllabus

- Design and implementation of AI/ML models for Text processing
- Design and implementation of AI/ML models for speech processing
- Design and implementation of AI/ML models for computer vision
- Design and implementation of AI/ML models for game playing
- Deploying ML models on hardware tools
- Developing applications with AI/ML development boards/kits/drones

Course Outline

Course Topics

- **Natural Language Processing**
  - Text & Speech Processing
  - Transformers for NLP Speech
- **Computer Vision**
  - Introduction to CV
  - Segmentation & Classification
- **Advanced Topics**
  - Reinforcement Learning: Game Design
  - Multimodality
  - *LLMs (Hands-on, optional)*

Lab Sessions

- **Hardware Assembly**
  - Lab 1: PC Assembly Booting
  - Lab 2: Drone Assembly Vision Setup
- **Robotics - Ground Vehicle**
  - Lab 3: Path Tracking
  - Lab 4-5: Collision Avoidance
- **Robotics - Aerial Drone**
  - Lab 6: Human Tracking
  - Lab 8: Advanced Maneuvers
- **Integrated Systems**
  - Lab 7: Real-time Recognition

Hardware Requirements

Core Compute Robotics

- **Primary Compute Modules**
  - Nvidia Jetson Nano Dev Kit (4GB)
  - Raspberry Pi 5 w/ Power Supply
  - Arduino Uno Rev3
  - ESP32 Development Board
- **Robotics Kits Chassis**
  - DIY JetBot Kit (for Jetson Nano)
  - Generic Robotic Car Chassis
- **Specialized AI Sensors**
  - HUSKYLENS
  - Arduino Nicla Vision

Peripherals Components

- **Sensors I/O**
  - Raspberry Pi Camera Module 3
  - USB Desktop Microphone
  - General Sensor Packet
- **Power System**
  - 18650 Li-ion Batteries (3000mAh)
  - 18650 Battery Holder Charger
  - USB Power Bank
- **Prototyping Tools**
  - Breadboard (840 points)
  - Jumper Wire Sets (M-M,

Required Libraries

- Audacity Software
- Python speech features
- Keras
- Tesseract Python library

Experiments

- Language Translation with Deep Learning
- Speaker Identification
- Face Detection
- Game Development (e.g., Hadron game)
- Path following robotic car
- And few Real world projects

Project Example: Language Translation with Deep Learning

Project Purpose

Build an RNN sequence-to-sequence model in Keras to translate a language A to language B.

- Sequence-to-sequence learning (Seq2Seq) converts sequences from one domain to another.
- The encoder LSTM turns input sequences into state vectors.
- The decoder LSTM generates target sequences based on the encoder's state vectors.
- In inference mode, the process involves encoding, decoding, and sampling characters until the end-of-sequence.

Introduction

Transformer is a deep learning architecture introduced by Vaswani et al. (2017) in the paper *"Attention is All You Need"*.

- Foundation for models like **BERT, GPT, T5, RoBERTa**.
- Revolutionized **Natural Language Processing (NLP)**.

Core Idea

- Traditional models (RNNs, LSTMs) process text **sequentially**.
- Transformers process **in parallel** using **self-attention**.
- Better for capturing **long-range dependencies**.

Transformer Architecture

- **Input Embeddings**: Word vectors + positional encoding.
- **Encoder-Decoder**:
  - Encoder (6 layers): Understands input.
  - Decoder (6 layers): Generates output.
- BERT uses **only encoder**, GPT uses **only decoder**.

Self-Attention Mechanism

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

- Allows attending to all words in the sentence.
- Q = Queries, K = Keys, V = Values.

Key Components

- **Multi-Head Attention**: Parallel attention layers.
- **Feed-Forward Network**: Applied at each position.
- **Layer Normalization & Residual Connections**:
  - Stabilizes training of deep networks.

Applications in NLP

Task	How Transformers Help
Machine Translation	Encoder-decoder setup
Text Classification	BERT/RoBERTa encoders
Question Answering	Contextual embeddings
Text Generation	GPT/T5 generate text
Summarization	Generate concise summaries
NER	Word-level classification (BERT)

Popular Transformer Models

Model	**Type**	**Usage**
BERT	Encoder	Classification, QA, NER
GPT (1/2/3/4)	Decoder	Text generation
T5	Enc-Dec	Summarization, translation
RoBERTa	Encoder	Better-trained BERT
XLNet	Encoder	Permuted LM, BERT++

Example: Hugging Face with BERT

```
from transformers import AutoTokenizer, AutoModelForSequenceClassifi
import torch

tokenizer = AutoTokenizer.from_pretrained("bert-base-uncased")
model = AutoModelForSequenceClassification.from_pretrained("bert-bas

inputs = tokenizer("Transformers are amazing!", return_tensors="pt")
outputs = model(**inputs)
logits = outputs.logits
```

Conclusion

- Transformers are powerful and efficient for NLP.
- Basis for modern models like BERT, GPT, T5.
- Great for tasks like classification, QA, generation.

Conclusion

This course offers a comprehensive and practical overview of implementing Artificial Intelligence and Machine Learning solutions, from text and speech processing to computer vision and hardware deployment.

Thank You!

rmundotiya@iitbhilai.ac.in