Intro to AI : Exploring Fundamentals, Research, and Career Opportunities

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My Introduction

- **4th year PhD** at **Rochester Institute of Technology (RIT)**, New York
- **Document and Pattern Recognition Lab (DPRL):** https://www.cs.rit.edu/~dprl/
- **Research Focus:** Pattern recognition, computer vision, natural language and speech processing
- **Research Applications:** math formula search engine in documents, drug discovery (medicine synthesis), chemical formula and reaction extraction
- **Work experiences:**
  - **Applied Scientist Intern** at **Amazon AI (Alexa),** Silicon Valley (California), US
  - **Machine Learning Engineer** at **Fusemachines,** Nepal
  - **Machine Learning Teaching Assistant** at **RIT**
  - **Computer Science (Foundations in AI) instructor** at Samriddhi College, Nepal

Foundations

AI is the broader concept of machines being able to carry out tasks in a way that we would consider "smart." It encompasses various technologies and approaches aimed at creating intelligent systems.

- **Machine Learning (ML):** AI systems that learn from data and improve over time. Example: Recommendation systems, like those used by Netflix or Amazon.
- **Natural Language Processing (NLP):** Enabling machines to understand and respond to human language. Example: Chatbots, language translation services.
- **Computer Vision:** Teaching machines to interpret and make decisions based on visual data. Example: Facial recognition, autonomous vehicles.

Foundations

Data Science is an interdisciplinary field that uses scientific methods, processes, algorithms, and systems to extract knowledge and insights from structured and unstructured data.

- **Data Collection:** Gathering data from various sources.
- **Data Cleaning:** Preprocessing data to remove noise and inconsistencies.
- **Data Analysis:** Applying statistical and computational techniques to understand data patterns.
- **Data Visualization:** Representing data insights visually through charts and graphs.
- **Data Modeling:** Building models to make predictions or decisions based on data.

Tools used: Python, R, Tableau, and so on.

Foundations

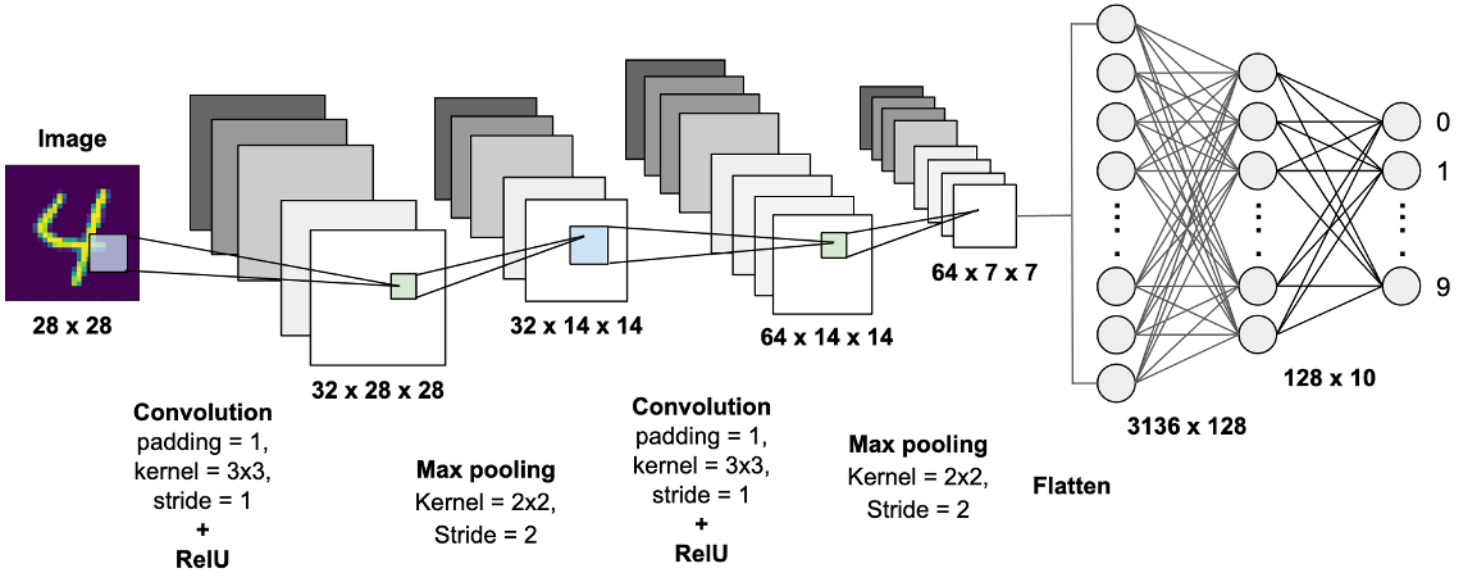
- Foundations of AI:
  - Linear Algebra
  - Probability and Statistics
  - Multi-variable Calculus
- Read, read, and read!!
  - Get up to date with current research progress and developments in AI
- Try to implement your own projects

Machine Learning

- Learning from Data: ML algorithms use data to learn patterns and make decisions or predictions.
- Neural Networks are a series of algorithms that mimic the operations of a human brain to recognize relationships between vast amounts of data.
- How Neural Networks Learn?

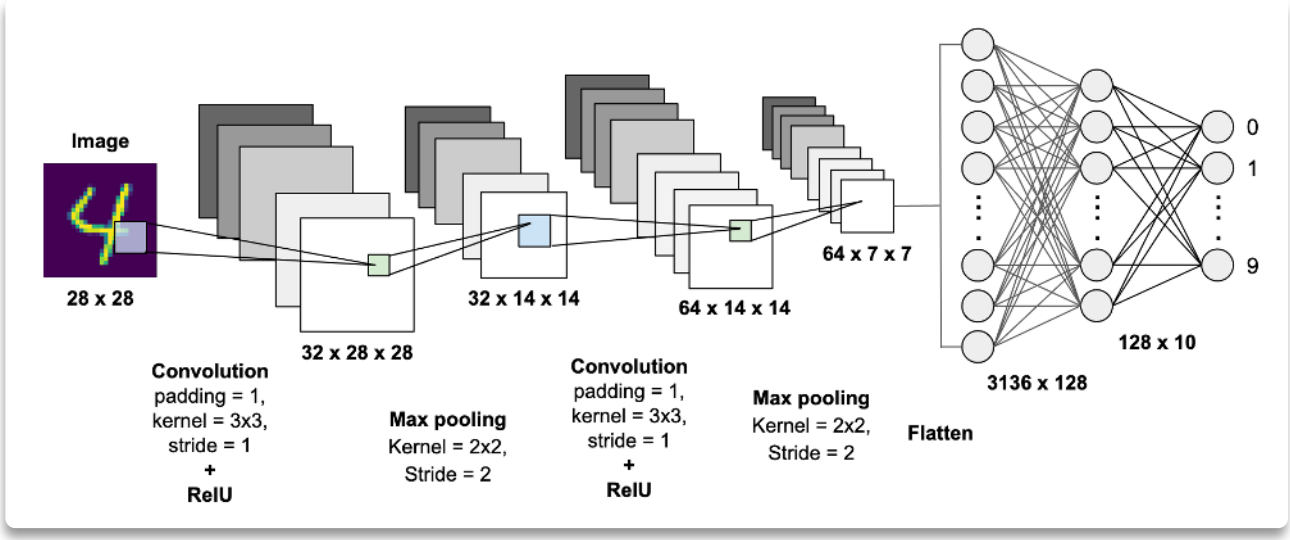
Machine Learning: Neural Networks

- **Input Layer:** Receives input data (e.g., images, text, audio).
- **Hidden Layers:** Perform computations and extract features. Each layer learns to detect different patterns.
- **Output Layer:** Produces the final output (e.g., classification, prediction).



Machine Learning: Training

- **Forward Propagation:** Data is passed through the network, and predictions are made.
- **Loss Calculation:** The difference between the predicted output and the actual output is calculated.
- **Backpropagation:** The network adjusts its weights based on the error using optimization algorithms (like Gradient Descent).
- **Iteration:** The process is repeated multiple times (epochs) to minimize the error and improve accuracy.



My Research

Some public tools built during my research available online (with code):

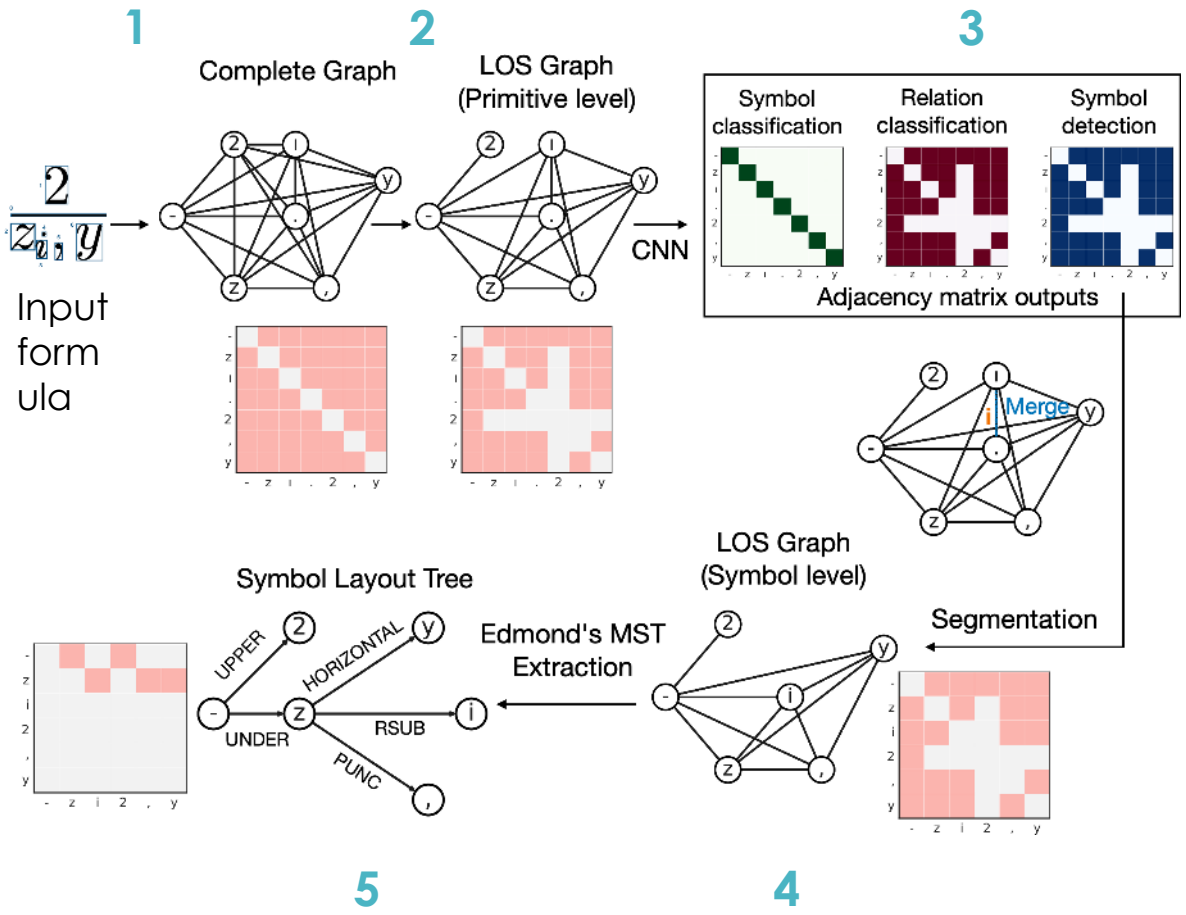
- **MathDeck:** Math + Text search in document corpus
  - **Demo:** https://demo.mathdeck.org/
  - **Code:** https://gitlab.com/dprl/mathdeck
  - **Paper:** https://shahayush.com/files/Amador2023_Search.pdf

- **ChemScraper:** Molecule extraction from documents
  - **Link:** https://chemscraper.platform.moleculemaker.org/configuration
  - **Code:** https://gitlab.com/dprl/graphics-extraction/-/tree/icdar2024
  - **Paper:** https://arxiv.org/abs/2311.12161

My Research: Math Recognition

Math Recognition using CNN:

1. **Construct** graph over CCs/strokes
2. **Prune:** Convert to LOS graph
3. **Classify** edges as merge/split and relationships, nodes as symbols
4. **New LOS graph:** detected symbols
5. **Extract MST** using Edmond's arborescence algorithm



ChemScraper

chemscraper.frontend.staging.mmli1.ncsa.illinois.edu/configuration

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Chemical molecule diagram extractor for PDF

Github

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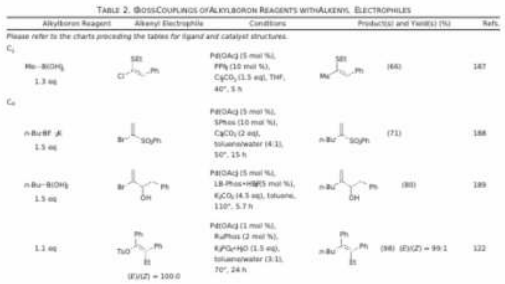

Analyze using ChemScraper →

Cite As: Shah A. K., Amador B. M., Dey A., Creekmore M., Ocampo B., Denmark S., and Zanibbi R. ChemScraper: Graphics Extraction, Molecular Diagram Parsing, and Annotated Data Generation for PDF Images (2023)

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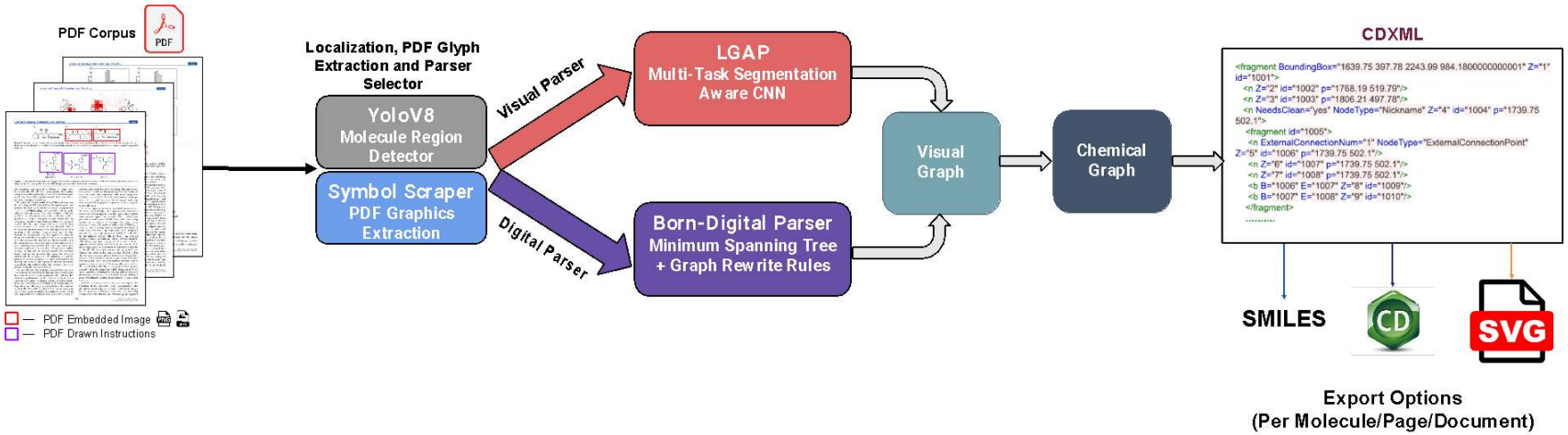
My Research: ChemScraper

1. **YOLOv8 Detector:** detect molecule regions
2. **Symbol Scraper:** extract character and graphics from PDF encodings
3. **Graph Construction and Transformations:**
   - **Born-digital parser:** extracts visual graph from PDF symbols
   - **Visual parser:** multi-task CNN (LGAP) extracts visual graph from Image primitives
4. **Chemical graph generation**



Career Opportunities & Job Market

- Current Job Trending in AI:
  - Large Language Models (LLMs): E.g., GPT-4, LLAMA
  - Vision-Language Models (VLMs): E.g., CLIP, DALL-E
  - Prompt Engineering
  - Artificial General Intelligence (AGI)

- Current Job Market
  - Getting Competitive day by day
  - Prepare accordingly

Career Opportunities & Job Market

- Internship and Job Search Tips
  - Start early
  - Data Structures and Algorithms concepts and coding (Leetcode)
  - Work on projects of your interests and focus on the fundamental concepts
  - Be up to date with current research and developments
  - Networking

- My experiences at Amazon
  - Hiring process
  - Work experience

Resources

Recommended Books:

- "Linear Algebra and Its Applications" by Gilbert Strang (YouTube Lecture Series also available)
- "Pattern Recognition and Machine Learning" by Christopher M. Bishop.
- "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville.
- "A First Course in Probability" by Sheldon Ross
- "The Elements of Statistical Learning" by Trevor Hastie, Robert Tibshirani, and Jerome Friedman.

Online Courses from

- Coursera, edX, Udacity, MIT OpenCourseWare
- Live Classes from Pana Academy

Let’s Discuss…

This is just the beginning of your adventure in AI and Data Science. Your curiosity and questions will drive your growth.

Let's dive deeper together. I'm ready for your questions!