Fluidic City Lab Preparation Materials

Level 1: Basics

1. **Linear Algebra:**
    - Complete the following tasks (useful link: Matrix Wiki, Google the topics for more):
        - Be able to explain what are vectors, matrices, and tensors
        - Be able to explain matrix addition, multiplication, and transposition
    - Videos on relevant topics (watch them in their entirety):
        - Vector Dot Product
        - Vector Cross Product
    - Videos on Linear Regression (watch them in their entirety):
        - Introduction to Linear Regression
        - Linear Regression, Clearly Explained

2. **Probability and Statistics:**
    - Videos on introductory topics (watch them in their entirety):
        - Probability Basics
        - Statistics Basics
        - Normal Distribution

    - Histograms

3. **Machine Learning:**
    - Videos on relevant topics (watch them in their entirety):
        - Neural Network
        - Gradient Descent
        - Back-Propagation
    - Reading materials (read as much as you can follow):
        - Activation Functions
        - Back-Propagation

4. **Reinforcement Learning:**
    - Video playlist (watch the course in its entirety):
        - DeepLizard's Intro to Reinforcement Learning
    - Reading materials (read in its entirety):
        - Deep Q Networks Paper

5. **Simulation of Urban MObility (SUMO):**
    - Complete the following tasks:
        - Be familiar with SUMO: Website, Documentation, GitHub. Be able to explain what is SUMO.
        - Be able to follow the instructions in SUMO GitHub and install SUMO in your system (launch `sumo-gui` from the terminal to verify).
        - Be able to understand XML code and able to create necessary XML files (node, edge, route, additional, sumocfg) and run a complete sumo network.

- Create intersection and roundabout environment in SUMO with 50000 vehicle flow.
- Learn to use some necessary editor of sumo such as Netedit
- Be familiar with traci connection with SUMO GUI using Python and try to learn the use of some of the common functions

6. **ML + RL Coding:**

- The pre-requisite for this sub-task is “intermediate knowledge of programming with Python”. If you want to brush up on your Python:
  - Follow the tutorials such as the one from Tutorials Point, to cover topics starting from Basic syntax up to Exception Handling and Object Oriented Programming (Classes and Objects).
  - You can use an online compiler to quickly get started.

- Complete the following tasks:
  - Be familiar with PyTorch and Tensorflow
  - Complete the PyTorch coding tutorials (In their entirety):
    - Deep Learning with PyTorch: A 60 Minute Blitz
    - Official PyTorch DQN Tutorial, Article
- Optional coding tutorial:
  - Train a Mario-Playing RL Agent, Article

Level 2: Advanced

- Everything in Level 1 and additionally the following:

1. **Linear Algebra:**

- Reading materials (as much as you can follow)
    - Chapter 2 of Deep Learning Book

2. **Probability and Statistics:**
    - Reading materials (as much as you can follow)
        - Chapter 3 of Deep Learning Book

3. **Machine Learning:**
    - Reading materials (as much as you can follow)
        - Chapter 5 of the Deep Learning book
        - The 100 page ML book

4. **Reinforcement Learning:**
    - Video playlist
        - Note: Both lecture series are 16 hours long so if time is a constraint, then prioritize Sergey Levine's lectures.
        - David Silver's Lectures (in its entirety)
        - Sergey Levine's Lectures (Lecture 4 to Lecture 16)

5. **Traffic + SUMO:**
    - Be able to explain fundamental properties of traffic
    - Be able to explain and differentiate what is a flow, trip and a route in SUMO
    - Be able to install and manage multiple versions of SUMO in your system.
    - Be familiar with tools built into SUMO such as: Traci, NetEdit, NetConvert, JTrouter and OSMwebwizard.

- Be able to setup and play around with one of the following SUMO + Reinforcement Learning) frameworks:
    - FLOW
    - SUMO-RL

6. **Coding:**
    - Setup (No specific tutorials will be provided for this, please use ChatGPT, Google to complete the objectives listed):

Sn.	Topic/ Skill	Objective
1.	Ubuntu	Be able to install Ubuntu on a new system and install drivers for accessories (WiFi, monitor, keyboard, mouse) to work.
2.	Nvidia Drivers	Be able to identify the GPU and install appropriate drivers and acceleration tools like CUDA, CuDNN. Be able to monitor GPU memory (nvidia-smi) and system usage (htop).
3.	Virtualization	Be able to create, modify, delete virtual environments with specific python versions using either Anaconda or Virtual env.
4.	Package Management	Be able to install and remove packages in a virtual environment using tools such as Pip. Be able to export the requirements of your current environment install packages from provided requirements.
5.	Linux terminal	Be familiar with writing and executing shell scripts. Be able to modify environment variables in a terminal profile (bashrc, zshrc).
6.	IDE	Be familiar with a modern IDE such as VSCode or IntelliJ.
7.	GitHub	Be familiar with basics of code management with Git: open issues, create pull requests, create branch, merge branch, stage files, commit, push, fetch, and pull.

7. **Academic Papers (as much as you can follow):**
    - The papers below present architectures which are milestones in the history of deep learning:
        - AlexNet Paper
        - ResNet Paper
    - The papers below introduce commonly used RL algorithms:
        - Rainbow DQN Paper
        - PPO Paper
    - The papers below are especially relevant to our lab:
        - FLOW Paper
        - Learning to Control and Coordinate Hybrid Traffic Through Robot Vehicles at Complex and Unsignalized Intersections

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Platforms/Applications Used

Paper Writing:

- Overleaf

Code Hosting and Collaboration:

- GitHub

Anonymize GitHub Repos (this is sometimes necessary when submitting papers):

- Anonymous GitHub

Image Editing:

- Sketch (Can get free with a .edu email)

Video Editing:

- Final Cut Pro (If using macOS; $300)
- HitFilm Express (Free)

Collaborative Document Editing and Note-Taking:

- Notion

Optional Materials

- Transformers
  - Transformer Paper
  - Transformers From Scratch