Report On
Assignment Part I – Artificial Intelligence

By

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Introduction

Understanding Constraint Satisfaction Problems (CSP)

Constraint Satisfaction Problems (CSPs) are a category of combinatorial problems essential in fields such as artificial intelligence, operations research, and computer science. The primary objective of a CSP is to identify an arrangement or selection from a predefined set of items that meets all given constraints.

One practical application of CSPs is in **timetable generation**, where the goal is to create schedules that effectively accommodate the numerous constraints of academic institutions, such as class types, time slots, sections, and credit requirements.

Understanding Constraints in CSPs

Constraints are the conditions or rules that must be satisfied for a solution to be considered valid. In the context of CSPs, constraints can vary widely depending on the specific problem being addressed. Here are a few examples in case of my chosen problem – timetable generation:

- **Types of Classes**: In an academic scheduling problem, constraints may include different class types such as lectures and practicals.
- **Time Slots**: Constraints may specify that certain classes must occur at specific times or that no two classes can occur simultaneously.
- **Sections**: In a larger educational context, constraints could dictate that students in the same section must have the same class schedule.
- **Credits**: For university course scheduling, constraints might include the credit load per semester or limits on the number of credits per class.

Combinatorial Explosion in CSPs

One of the significant challenges in solving CSPs is the combinatorial explosion. As the number of items within the problem increases, the number of possible combinations of those items grows exponentially. This exponential growth vastly increases the complexity of the problem, making it more challenging to find a solution efficiently. The term "combinatorial explosion" refers to this rapid growth in the number of potential solutions, which often outpaces the increase in problem size, leading to increased computational demands and difficulty in problem-solving.

Methodology

Plan of work

Students at BPDC get an academic timetable from college that shows when courses occur, who teaches them, the various sections, electives to choose and so on in a PDF format.

BITS PILANI, DUBAI CAMPUS

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II. COURSEWISE TIMETABLE — SECOND SEMESTER 2023-24

COM COD	COURSE NO.	COURSE TITLE	CREDIT L P U	SEC	INSTRUCTOR-IN-CHARGE/ Instructor	ROOM	DAYS/ HOURS	MIDSEM TEST	COMRE DATE & SESSION
2420	AN F311	PRINCIPLES OF AERODYNAMICS	3 0 3	1	MAJID H KHAN	276	M6 T2 F1	03.04.2024 FN	04.06.2024 AN
1001	BIO F110	BIOLOGY LABORATORY	0 2 1		NEERU SOOD				
				1	Aditya Sharma	307	M34		
				2	Neeru Sood	307	M89		
				3	Debostuti Ghosh	307	T34		
				4	Neeru Sood	307	W12		
				5	Aditya Sharma	307	Th34		
				6	Aditya Sharma	307	F12		
				7	Neeru Sood	307	F34		
1002	BIO F111	GENERAL BIOLOGY	3 0 3		DEBOSTUTI GHOSH			01.04.2024 FN	04.06.2024 FN
				1	Neeru Sood	101	M2 T2 Th5 F1		
				2	Mainak Dutta	105	T2 W1 Th5 F4		
				3	Debostuti Ghosh	123	T1 W4 Th5 F4		
1359	BIOT F241	GENETIC ENGINEERING TECH	1 3 4	1	PALLAB SANPUI	220	Th4	29.03.2024 FN	29.05.2024 FN
		Practical		1	Pallab Sanpui	307	T789		
				1	Pallab Sanpui	307	W345		
				2	Arun Kumar Upadhyay	307	W789		
				2	Arun Kumar Upadhyay	307	Th789		
1103	BIOT F243	GENETICS	3 0 3	1	ADITYA SHARMA	220	M8 T3 W2 Th1	01.04.2024 AN	31.05.2024 FN
1361	BIOT F244	INSTRU METHODS OF ANALYSIS	1 3 4		MAINAK DUTTA			03.04.2024 AN	03.06.2024 AN
				1	S Ramachandran	220	M2		
		Practical		1	Mainak Dutta/S Ramachandran	308	T789		
				1	Mainak Dutta/S Ramachandran	308	W345		

Fig 1: A Section of Timetable Provided

The aim is to create a webapp which can take in details of the student like discipline, year, semester, and this pdf – and output a timetable which can be subject to constraints like section, electives chosen etc. Here's the code to this: https://github.com/Secret-Ambush/AI-project/tree/main/Timetable%20generator

Handling PDFs

The first step is to understand how to read the input file, and process it. As given in Fig 1, the timetable is in tabular format. Python has two libraries *fitz* (also known as *PyMuPDF*), *tabula* which can help in processing the PDFs. Finally, analysing it into a dataframe requires some manipulations like removing the header rows etc.

Creating a Sensible Dataframe

As it is noticible from the PDF there are many blank spaces – for example the course name is mentioned once, and the next rows aren't having it. This is understandable to us, but not

to a dataframe. Linearly filling the dataframe is the answer. This helps in extending the course no, course title, credits down.

The next step is Practicals which come up under a course name. It's implied that it belongs to the previously mentioned course, but this has to be ensured in the dataframe as well. The codes for all this are on my Github Repo which is mentioned at the beginning of this section.

Next step is mapping the Days/ Hours section. Here it is given as M4, T45 which mean Monday 4th hour, Tuesday 4th, 5th hours. This mapping has to be created.

Now, there are some rows with which there are no rooms are assigned – we can safely assume that there will be no conflict with the timetable – so these can be removed.

With this, the dataframe is ready.

Creating a CSP

Python's library *constraint* is the best way to solve CSP. Now, it's a matter of defining the variables, constraints and adding the no_overlap function. Here, I have to add all the courses (lectures, practicals) and all the unique sections as variables. For constraints, ensure that the student is enrolled in at least one section of each complsory course (practicals of core courses if applicable) and ensure that course timings don't clash.

Building the timetable

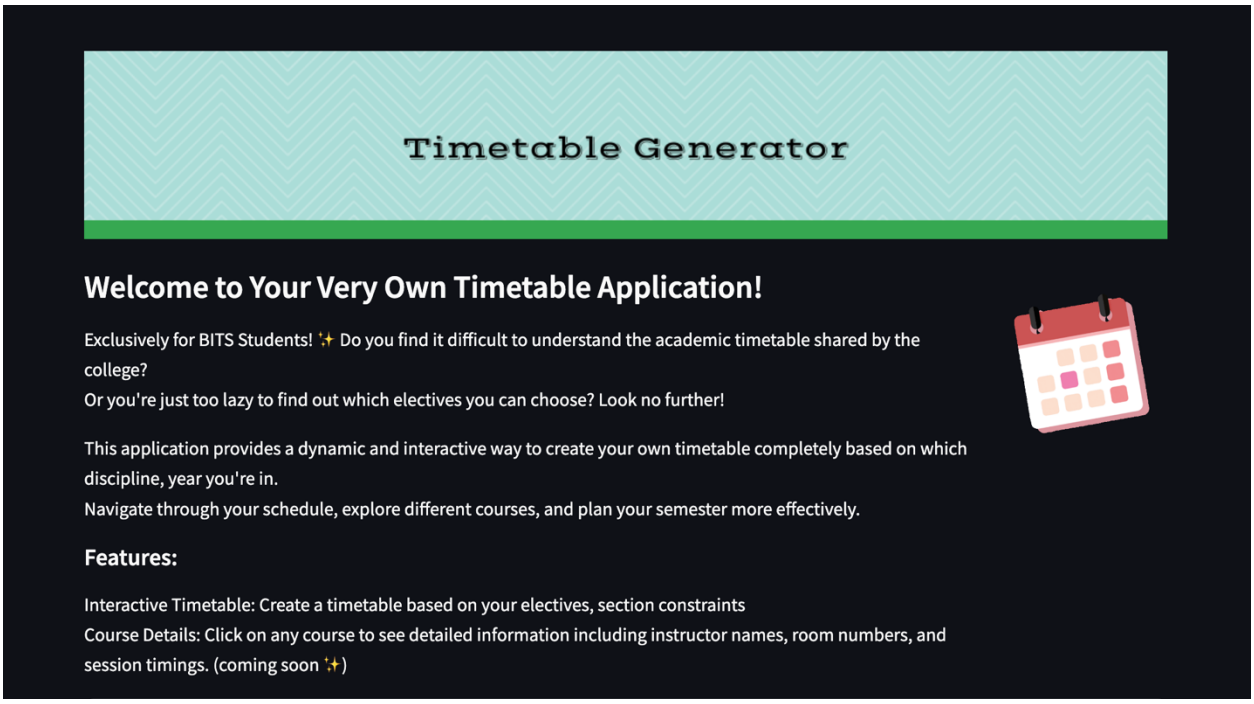
The solution is presented in the form of a dictionary. Now the course title, section details, time slots have to be extracted and converted into a dataframe. I have a timeslots dictonary which has the number of slots/periods per day. Now, I map the solution to this and whenever there is a match and ensure the course name and section are placed. Finally, the dataframe is ready. Using *Pandas Styler*, I can style the dataframe such that if there is an elective or practical – you can highlight it.

Building an interface

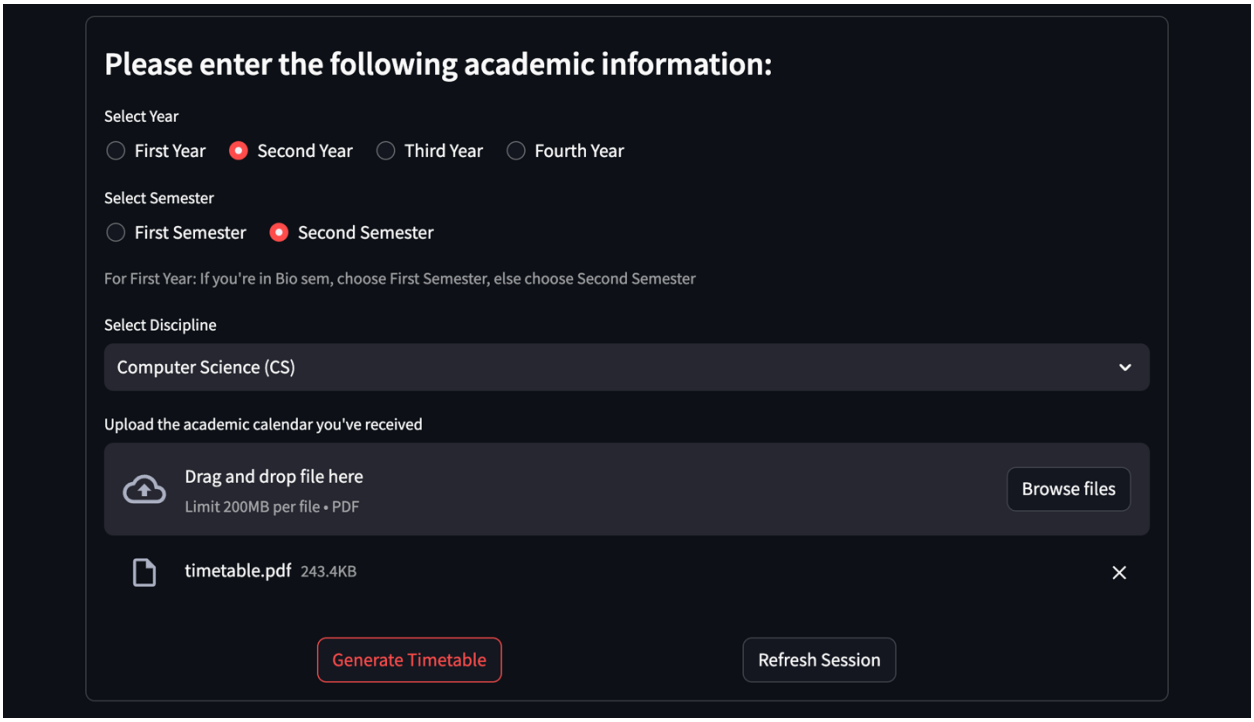
Now, comes the tricky part – how to ensure that the user is able to add dynamically constraints based on their year, semester. I built a streamlit interface to collect this data. In streamlit, using buttons and other utils refreshes the session – which will be an issue as we want the constraints to be retained. For this, *session_state* is used to retain variables like year, semester, section, timetable generated, constraint, electives. Handling this and updating based on the year is quite complicated but I was able to manage it. My code

illustrates how this was done. There is an option to download the final timetable as a csv as well.

Images of the interface



Choosing Second Year – Second Semester



Generating General Timetable without Constraints

	Monday	Tuesday	Wednesday	Thursday	Friday
1					MICROPROC & INTERFACING (Sec 4)
2			DATA STRUCTURES & ALGO (Sec 4)	ENVIRONMENTAL STUDIES (Sec 4.0)	
3	MICROPROC & INTERFACING (Sec 4)		MICROPROC & INTERFACING (Sec 4)	DATA STRUCTURES & ALGO Practical (Sec 4)	MICROPROC & INTERFACING Practical (Sec 5)
4		ENVIRONMENTAL STUDIES (Sec 4.0)	ENVIRONMENTAL STUDIES (Sec 4.0)	DATA STRUCTURES & ALGO Practical (Sec 4)	MICROPROC & INTERFACING Practical (Sec 5)
5	DATA STRUCTURES & ALGO (Sec 4)	DATABASE SYSTEMS (Sec 4)		DATA STRUCTURES & ALGO (Sec 4)	DATA STRUCTURES & ALGO (Sec 4)
6	DATABASE SYSTEMS (Sec 4)			MICROPROC & INTERFACING (Sec 4)	
7					
8		DATABASE SYSTEMS Practical (Sec 2)		DATABASE SYSTEMS (Sec 4)	
9		DATABASE SYSTEMS Practical (Sec 2)	DATABASE SYSTEMS (Sec 4)		

Download Timetable

Choosing Electives

Electives Chosen:

- **PRINCIPLES OF MANAGEMENT**: Sec 1.0
- **LINGUISTICS**: Sec 1

Add electives?

Select an elective:

PRINCIPLES OF ECONOMICS PRINCIPLES OF MANAGEMENT

Select a section:

1.0

Add Electives and Generate Clear All Electives

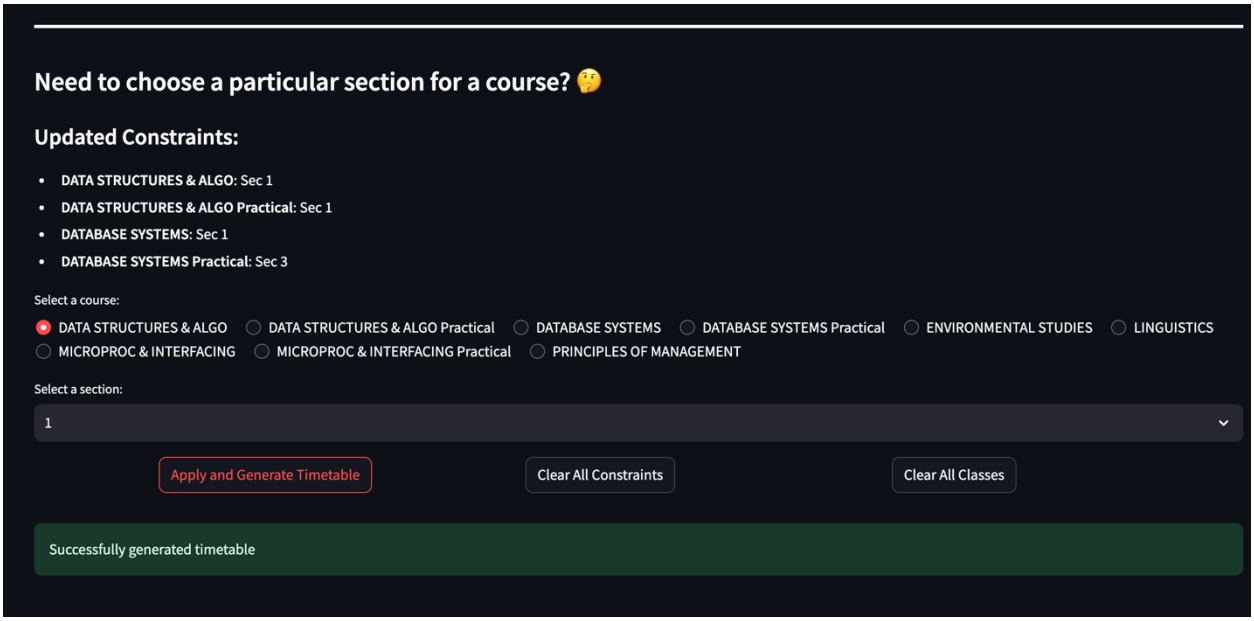
Add humanities electives?

Select a humanities elective:

ECOCRITICISM HUM RIGHTS HIST THEO PRA INTERNATIONAL LAW INTRO TO DEV STUDIES INTRO TO ISLAMIC ECONOMY INTRODUCTION TO ARABIC
LINGUISTICS SCIENCE OF SUSTAINABLE HAPPINESS

Add Hum Electives and Generate Clear All Hum Electives

Applying Section Constraints

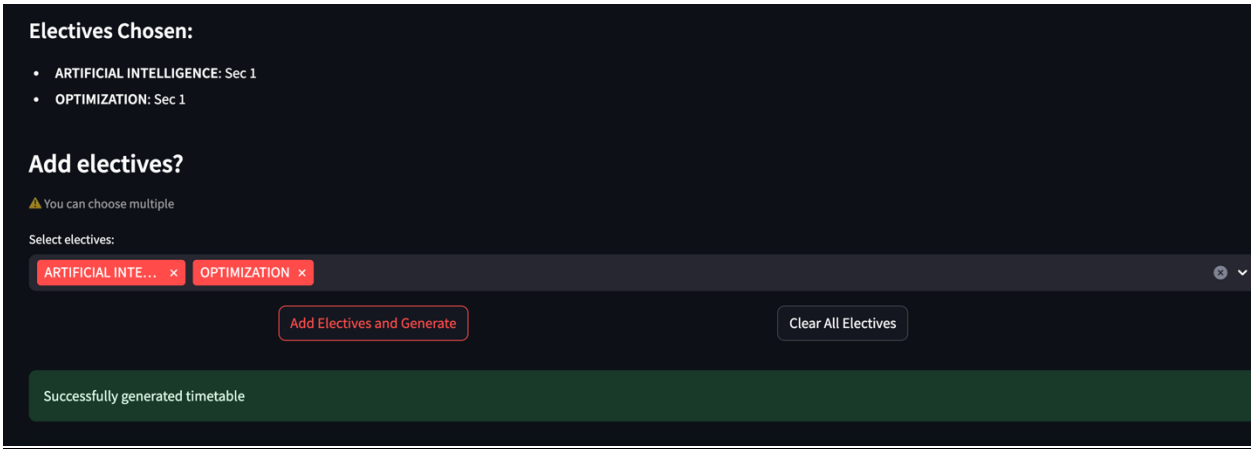


Generating Table Based on Electives and Constraints

	Monday	Tuesday	Wednesday	Thursday	Friday
1		PRINCIPLES OF MANAGEMENT (Sec 1.0)	LINGUISTICS (Sec 1)		MICROPROC & INTERFACING (Sec 4)
2	DATABASE SYSTEMS (Sec 1)	DATA STRUCTURES & ALGO (Sec 1)		ENVIRONMENTAL STUDIES (Sec 4.0)	LINGUISTICS (Sec 1)
3	MICROPROC & INTERFACING (Sec 4)		MICROPROC & INTERFACING (Sec 4)	DATA STRUCTURES & ALGO (Sec 1)	DATABASE SYSTEMS (Sec 1)
4	LINGUISTICS (Sec 1)	ENVIRONMENTAL STUDIES (Sec 4.0)	ENVIRONMENTAL STUDIES (Sec 4.0)	DATABASE SYSTEMS (Sec 1)	
5	PRINCIPLES OF MANAGEMENT (Sec 1.0)	DATABASE SYSTEMS (Sec 1)	DATA STRUCTURES & ALGO (Sec 1)	PRINCIPLES OF MANAGEMENT (Sec 1.0)	DATA STRUCTURES & ALGO (Sec 1)
6				MICROPROC & INTERFACING (Sec 4)	
7					
8	DATA STRUCTURES & ALGO Practical (Sec 1)		DATABASE SYSTEMS Practical (Sec 3)	MICROPROC & INTERFACING Practical (Sec 4)	
9	DATA STRUCTURES & ALGO Practical (Sec 1)		DATABASE SYSTEMS Practical (Sec 3)	MICROPROC & INTERFACING Practical (Sec 4)	

Download Timetable 📚

Choosing Third Year – Second Semester



	Monday	Tuesday	Wednesday	Thursday	Friday
1	DESIGN & ANAL OF ALGO (Sec 1)	OPTIMIZATION (Sec 1)		COMPUTER NETWORKS (Sec 1)	ARTIFICIAL INTELLIGENCE (Sec 1)
2		ARTIFICIAL INTELLIGENCE (Sec 1)	DESIGN & ANAL OF ALGO (Sec 1)	COMPILER CONSTRUCTION (Sec 1)	
3		COMPUTER NETWORKS (Sec 1)	COMPUTER NETWORKS Practical (Sec 1)		
4	COMPUTER NETWORKS (Sec 1)		COMPUTER NETWORKS Practical (Sec 1)		
5		COMPILER CONSTRUCTION (Sec 1)	ARTIFICIAL INTELLIGENCE (Sec 1)	DESIGN & ANAL OF ALGO (Sec 1)	OPTIMIZATION (Sec 1)
6		DESIGN & ANAL OF ALGO (Sec 1)	COMPUTER NETWORKS (Sec 1)		
7				OPTIMIZATION (Sec 1)	
8				COMPILER CONSTRUCTION Practical (Sec 2)	
9	COMPILER CONSTRUCTION (Sec 1)			COMPILER CONSTRUCTION Practical (Sec 2)	

Download Timetable