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ASSIGNMENT# 2

Artificial Intelligence for Engineers (CE-351)

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Contents

Abstract:

This study explores the application of artificial intelligence techniques to solve real-world problems, focusing on Constraint Satisfaction Problems (CSPs). Specifically, the research investigates the use of CSPs to address the complex task of designing degree programs and scheduling courses within higher education institutions. The Air University (AU) aims to introduce a new Bachelor of Science program in Judgment Day Prevention (JDP), which entails a set of courses and graduation requirements. Leveraging CSPs, the study develops a computational model to assist students in efficiently planning their academic journey while satisfying all degree requirements and constraints. Through constraint propagation and search algorithms, the study demonstrates how CSPs can provide optimal solutions to such educational planning challenges.

Problem Statement:

Implement artificial intelligence techniques on constraint satisfaction problems (CSPs) to solve real problems and derive valid conclusions.

Air University (AU) wants to start a new degree program, B.S in Judgment Day Prevention (JDP). Suppose the degree program is associated with the following courses.

- CE-211 Fundamental Data Structures and Algorithms
- CE-212 Principles of Programming
- CE-381 Artificial Intelligence for Engineers
- EE-681 Machine Learning
- EE-310 Logic and Computation
- MTH-484 Graph Theory
- HUM-122 Accounting
- HUM-311 Organizational Behavior
- EE-601 Information Warfare
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In order to graduate from the degree program, one must complete the following four requirements.

- Algorithms Requirement: (CE-211 AND CE-212) OR (CE-211 AND CE-381) OR (EE-681 AND MTH-484)
- Machine Learning Requirement: CE-381 OR EE-681 OR EE-310
- Communications Requirement: MTH-484 OR HUM-311 OR HUM-122
- Information Warfare Requirement: CE-381 OR EE-601

In addition, the department imposes the following restrictions:

- Information Aggressiveness Restriction: So that they can't make their programs TOO smart, students can take only one class from the set CE-381, EE-681, and EE-601.
- Basic Arithmetic Restriction: Students can't take both CE-211 and HUM-122.
- Organization Restriction: Students can't take both MTH-484 and HUM-311.

Finally, courses cannot be used to count towards multiple graduation requirements - so if you use CE-381 to fulfil part of the Algorithms requirement it can't count towards either the Machine Learning Requirement or the Information Warfare Requirement.

Introduction:

In the realm of higher education administration, designing degree programs and scheduling courses pose intricate challenges due to various constraints and requirements. The Air University (AU) faces a similar dilemma as it endeavors to establish a Bachelor of Science program in Judgment Day Prevention (JDP). The successful implementation of this program necessitates careful consideration of course offerings, graduation requirements, and student preferences. To address this complex task, artificial intelligence techniques offer promising solutions, particularly in the form of Constraint Satisfaction Problems (CSPs).

In this study, we delve into the application of CSPs to the JDP degree program at AU. We start by delineating the program's course offerings and graduation requirements, including prerequisites and restrictions imposed by the department. Subsequently, we formulate the problem as a CSP, with the aim of finding an optimal course schedule for students to fulfill all degree requirements efficiently. The CSP model encompasses variables representing different requirements, along with constraints dictating permissible course combinations and limitations on course selections.

Through the lens of CSPs, we tackle three key objectives. First, we model Ahmad Shah's academic journey within the JDP program, aiming to find an optimal set of courses to satisfy all graduation requirements. Second, we employ depth-first search (DFS) with backtracking to demonstrate the computational process of finding feasible course schedules while adhering to constraints. Lastly, we explore constraint propagation techniques to infer additional course selections for Ahmad Shah based on his prior coursework, paving the way for a schedule that meets all constraints without exhaustive search.

By harnessing the power of artificial intelligence and CSPs, this study elucidates the potential of computational methods in optimizing educational planning processes, thereby facilitating the efficient delivery of degree programs and enhancing student academic experiences.

Tasks:

Task 1:

Ahmad Shah just started his first year at AU, and needs to graduate as soon as possible. Suppose all he has left to take are JDP required classes. Model the problem of his trying to find a set of classes to satisfy all requirements as a CSP (Hint: the requirements should be your variables). What are the initial domains for each of your variables?

Variable:

We have 5 variables:

- AR1 (Algorithms Requirement 1)
- AR2 (Algorithms Requirement 2)
- MLR (Machine Learning Requirement)
- CR (Communications Requirement)
- IWR (Information Warfare Requirement)

Constraints:

The constraints ensure that each requirement is fulfilled without violating any imposed restrictions, such as taking only one course from a set or avoiding double counting.

- Information Aggressiveness Restriction (IAR):
  At most one of the courses (CE-381), (EE-681), and (EE-601) can be assigned to the 5 variables.
- Basic Arithmetic Restriction (BAR):
  At most one of the courses (CE-211) and (HUM-122) can be assigned to the 5 variables.
- Organization Restriction (OR):
  At most one of the courses (MTH-484) and (HUM-311) can be assigned to the 5 variables.
- No double counting:
  If a course is assigned to one variable, it cannot be assigned to another variable.

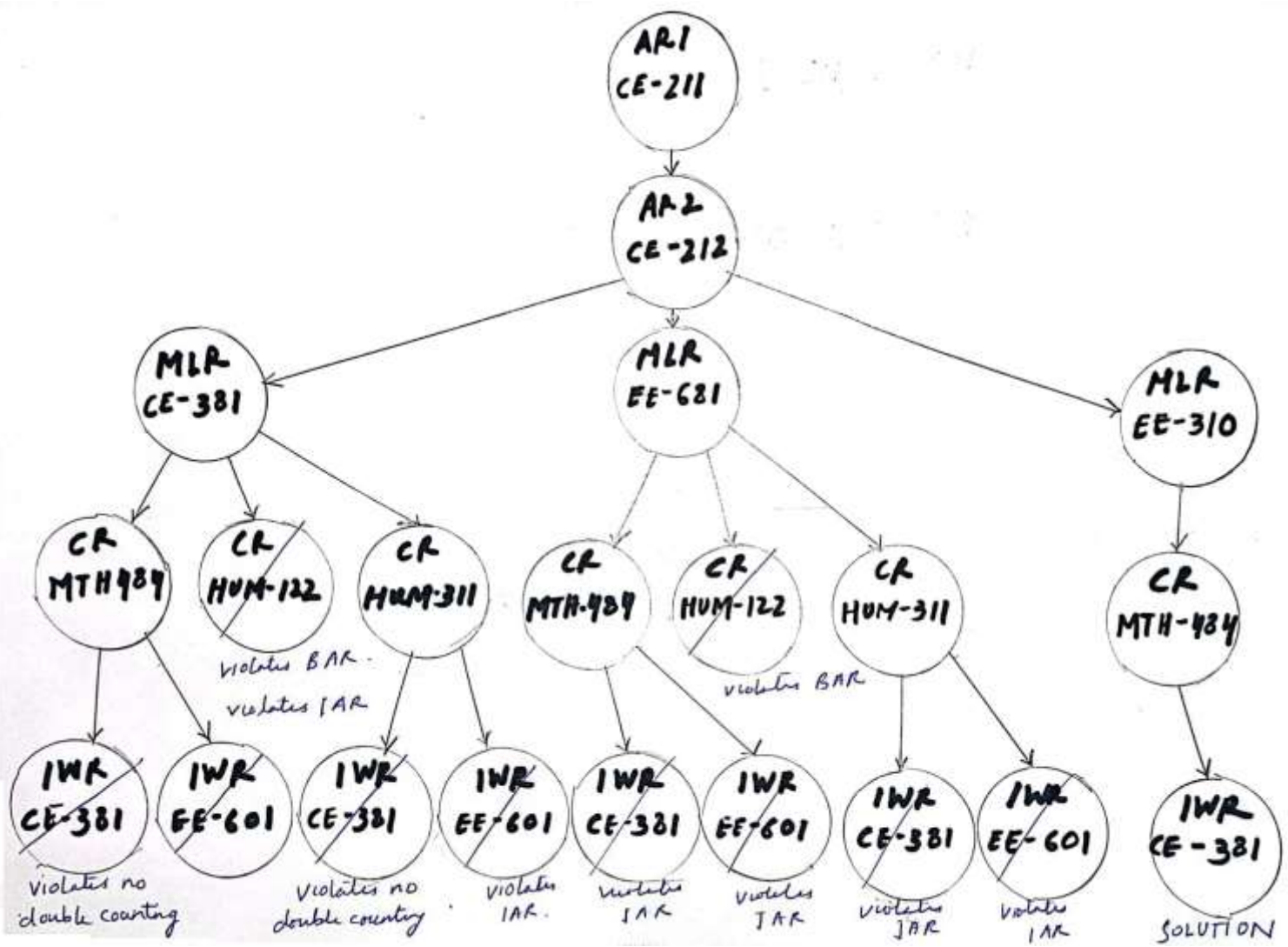
Initial Domains:

The initial domains represent the available options for each requirement.

- AR1: {CE-211, CE-212, CE-381, EE-681, MTH-484}
- AR2: {CE-211, CE-212, CE-381, EE-681, MTH-484}
- MLR: {CE-381, EE-681, EE-310}
- CR: {MTH-484, HUM-122, HUM-311}
- IWR: {CE-381, EE-601}

Task 2:

Show a depth-first search (DFS) with backtracking tree for finding a set of classes that fulfil all requirements using a variable order of the requirements in the order they are listed above, and using a value order that selects the lowest department/course number remaining in a variable's domain. Indicate which constraints were violated whenever the DFS needs to backtrack. (Note: to get full credit you must show the full DFS tree and not just the classes that are used to fulfil each requirement).



Task 3:

Suppose Ahmad Shah has already taken EE-601 towards his Information Warfare Requirement and CE-211 towards his Algorithms Requirement. Use constraint propagation to determine other classes he must take to graduate - indicate which requirements the classes fulfil. Can you create a schedule that satisfies all constraints without using search?

Constraint Propagation:

Information Warfare Requirement (IWR):

- Ahmad has already taken EE-601, satisfying this requirement.

Algorithms Requirement (AR):

- Ahmad has taken CE-211, fulfilling part of the Algorithms Requirement. Now, we need to fulfill the remaining part of the Algorithms Requirement, which is represented by AR2.
- Since CE-211 is taken, the remaining options for AR2 are {CE-212, CE-381, EE-681, MTH-484}.
- However, due to the Information Aggressiveness Restriction (IAR), only one course from the set {CE-381, EE-681, EE-601} can be taken. EE-601 has already been taken, so we can't select EE-681 or CE-381 for AR2.
- Hence, AR2's domain reduces to {CE-212, MTH-484}.

Machine Learning Requirement (MLR):

- Since EE-681 was a potential option for fulfilling the Machine Learning Requirement, but it was already used to fulfill part of the Algorithms Requirement, MLR's domain doesn't change.
- MLR's domain remains {EE-310}.

Communications Requirement (CR):

- We still need to fulfill the Communications Requirement.
- The options for CR are {MTH-484, HUM-311}.
- However, due to the Organization Restriction (OR), we can't select both MTH-484 and HUM-311.
- Therefore, CR's domain remains unchanged: {MTH-484, HUM-311}.

Schedule:

Constraint propagation helps us determine that Ahmad Shah needs to take the following classes to graduate:

AR1: CE-211 (already enrolled)

AR2: CE-212

MLR: EE-310

CR: MTH-484 or HUM-311 (decision required to choose one due to BAR)

IWR: EE-601 (already enrolled)

However, a decision needs to be made between MTH-484 and HUM-311 to fulfill the Communications Requirement, which may require search to find the optimal solution while satisfying all constraints.

Conclusion:

In conclusion, the task of designing a degree program, B.S. in Judgment Day Prevention (JDP), for Air University (AU) involved solving a Constraint Satisfaction Problem (CSP) using artificial intelligence techniques. By formulating the problem as a CSP and applying constraint propagation, we were able to determine a viable course schedule for Ahmad Shah to fulfill his degree requirements.

Through constraint propagation, we determined the remaining courses Ahmad Shah needed to take, given that he had already completed some requirements. By adhering to constraints such as the Information Aggressiveness Restriction, Basic Arithmetic Restriction, and Organization Restriction, we ensured that Ahmad's course selections met the specified criteria without violating any constraints.

Ultimately, Ahmad Shah needs to take Principles of Programming (CE-212), Logic and Computation (EE-310), and either Graph Theory (MTH-484) or Organizational Behavior (HUM-311) to complete his degree requirements. However, a decision between Graph Theory and Organizational Behavior must be made to fulfill the Communications Requirement, which may require further exploration through search techniques to find the optimal solution while satisfying all constraints.

This task illustrates the practical application of artificial intelligence techniques, specifically CSP-solving methods, in solving real-world problems such as academic course planning. Through careful modeling and constraint propagation, we can efficiently derive valid conclusions and make informed decisions to address complex requirements and constraints in educational settings.