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| **Department** | **Level** | **ID** | **Name** |  |
|  |  |  |  | **1** |
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AI phase 1,2 documentation

IDEA DESCRIPTION

The project aims to solve a faculty timetable scheduling problem using differential evolution.

The problem discussed is an NP-hard problem of generating a valid and highly optimal timetable for a faculty.

By valid we mean that there are no conflicts in the timetable, i.e. no two classes are in the same classroom at the same time, nor can a professor hold two classes at the same time, etc. Next, we describe the specific timetable format we will be analyzing. Classes are defined in the following fashion:

* Courses that is being taught
* The professor conducting the class
* All the student groups listening to the class together at the same time
* Length (1 to 4 hours) We assume that all classrooms are of the same size and have the required capacity. Valid hours for holding classes are from 9am to 6pm.

The task at hand is to assign a time and classroom for each of the classes given in the mentioned format.

FUNCTIONS

1. Assign classes to appropriate classrooms.
2. Assign proper time frame for each class.
3. Assign lecturers to their classes.
4. Ensure no classes are assigned more students than their capacity.
5. Ensure the most optimal schedule is generated based on the input data.

REAL WORLD APPLICATION

This is an application in South Africa regarding scheduling of nurses using a differential evolution approach.

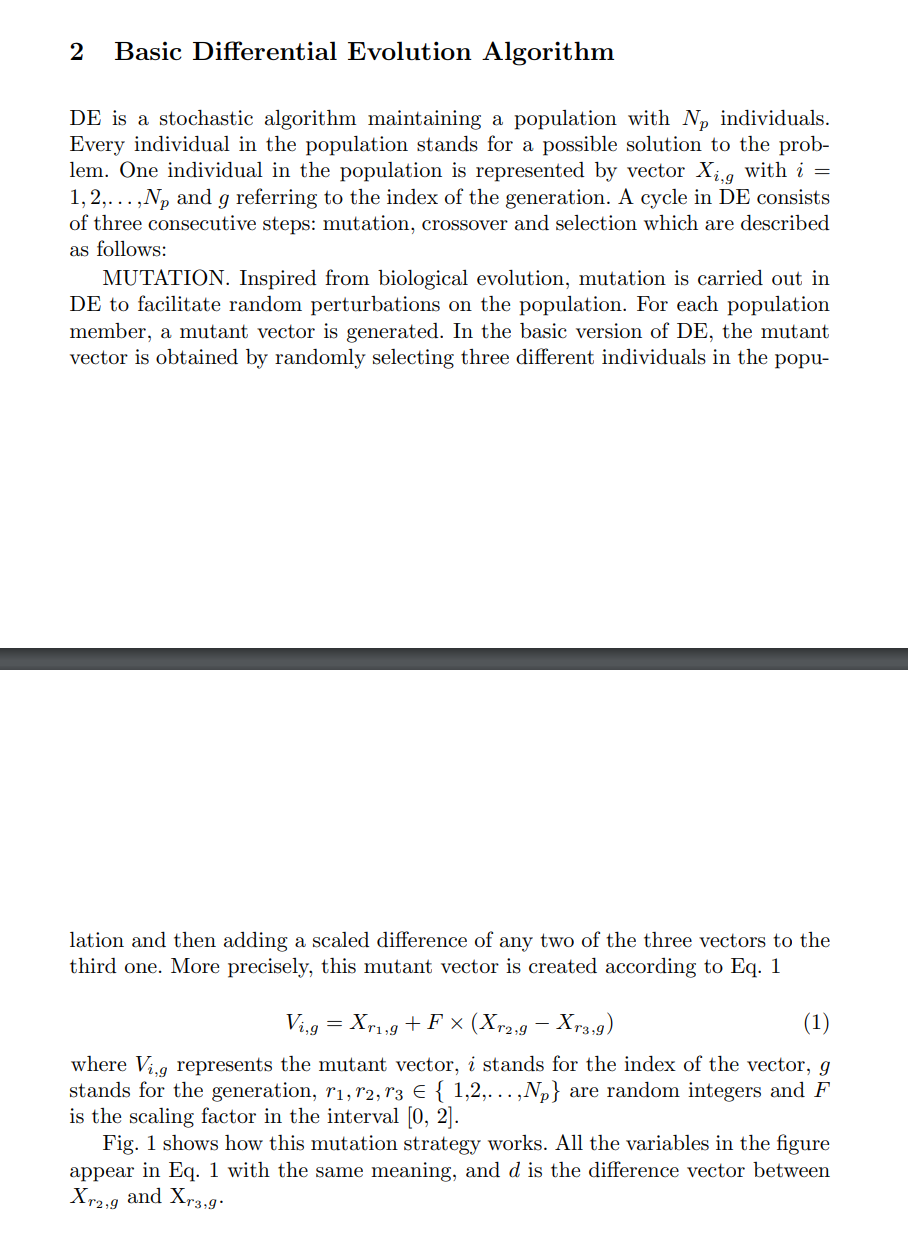
🡺<http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S2224-78902012000300008>

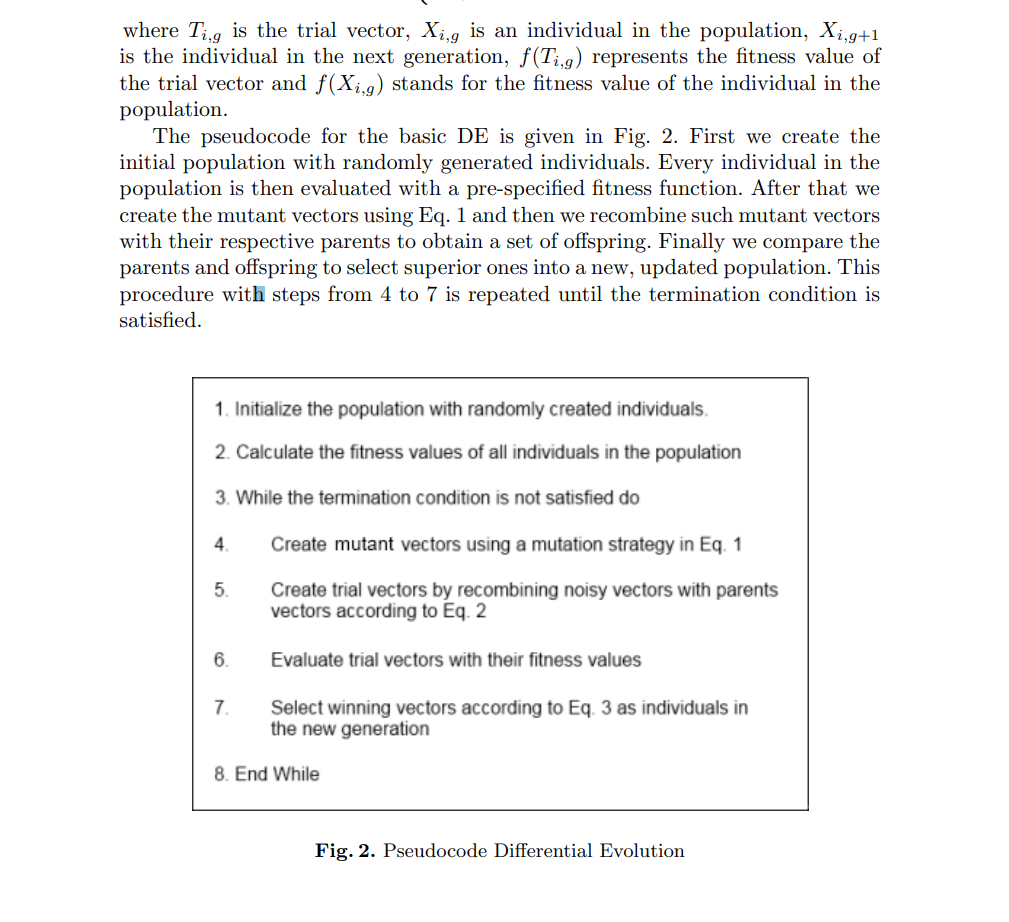
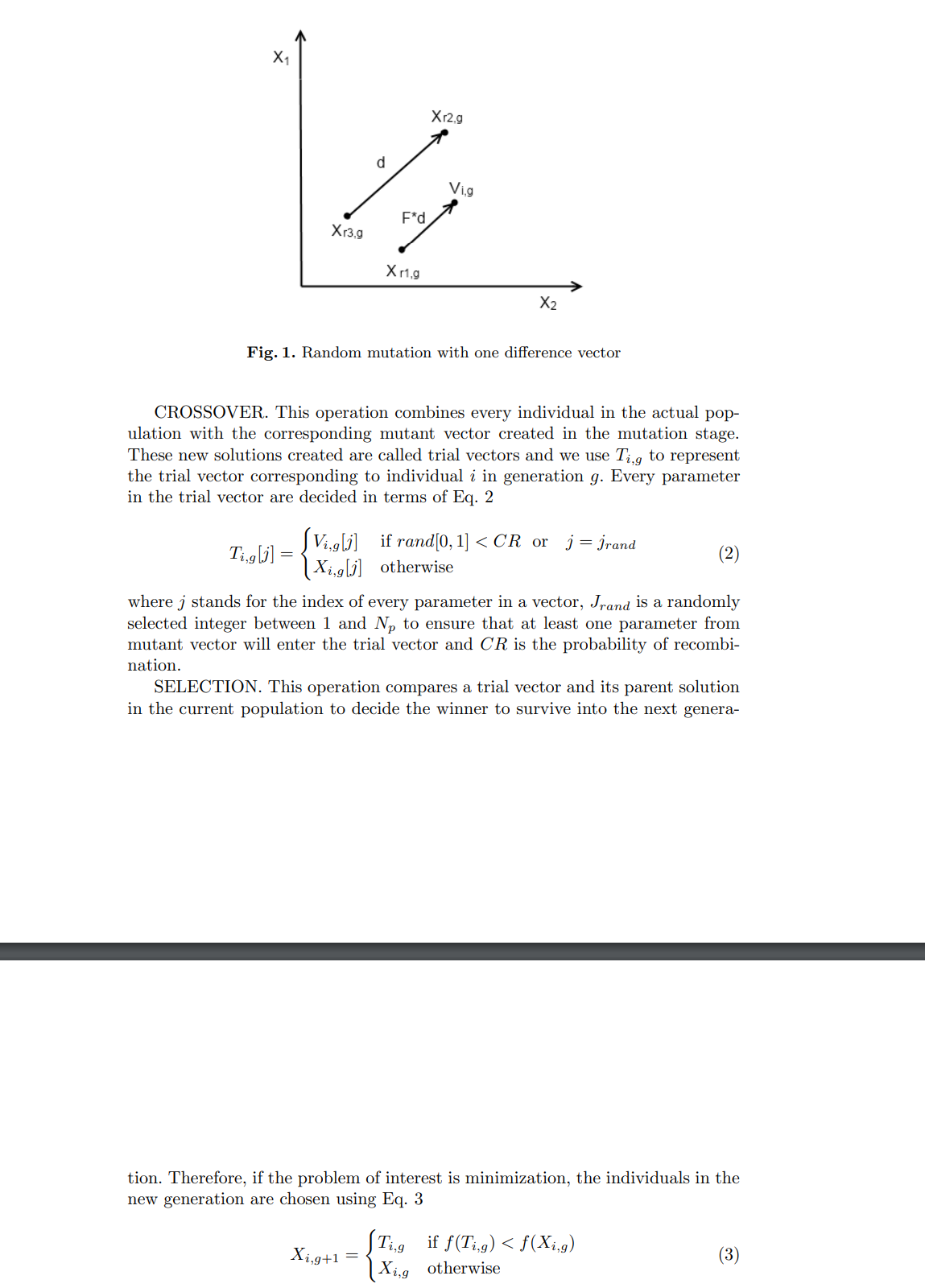
This is an application on the scheduling of generator maintenance in Nigeria.

* <https://core.ac.uk/reader/229178154>



ACADEMIC LITERATURE RIVEIW



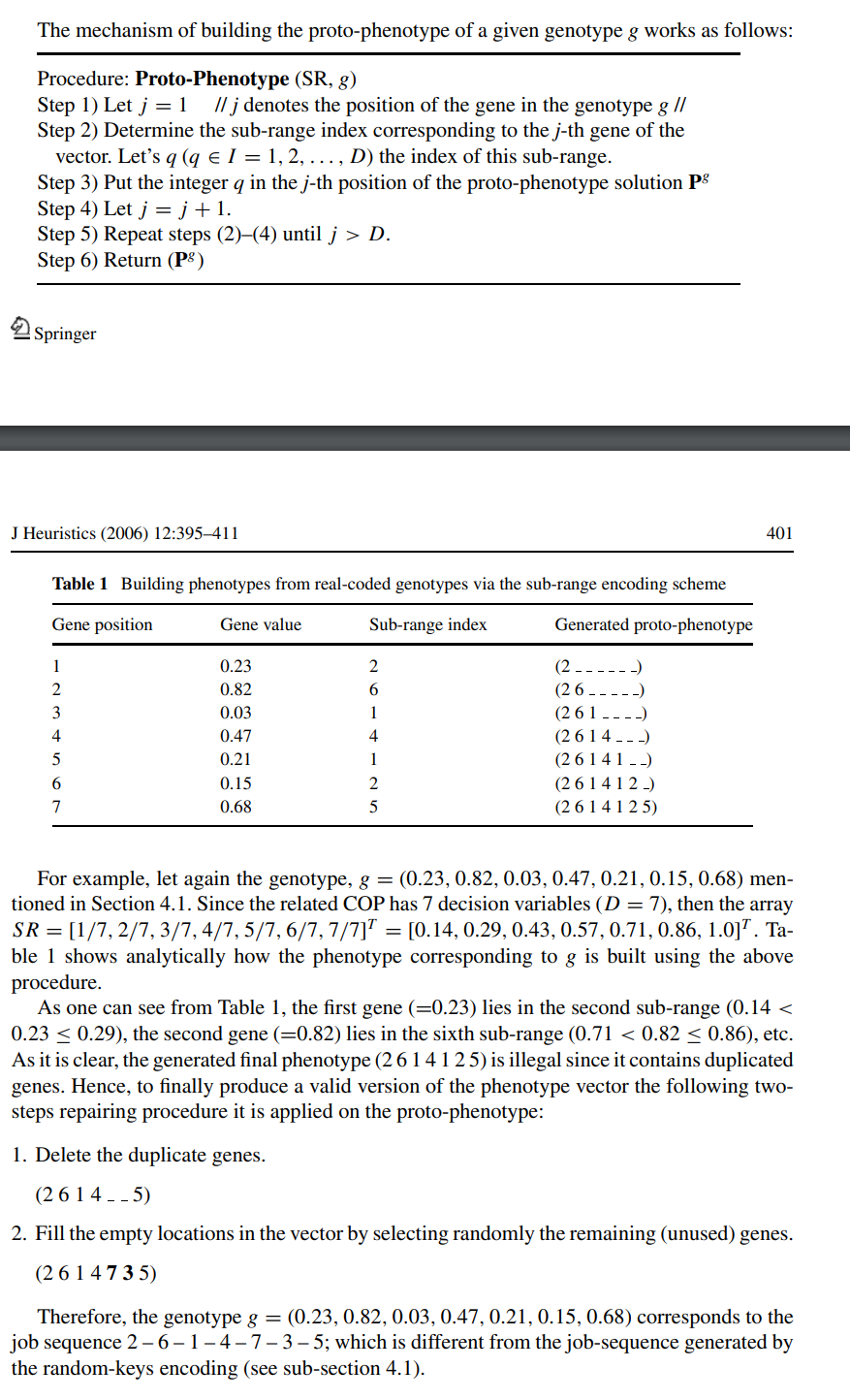


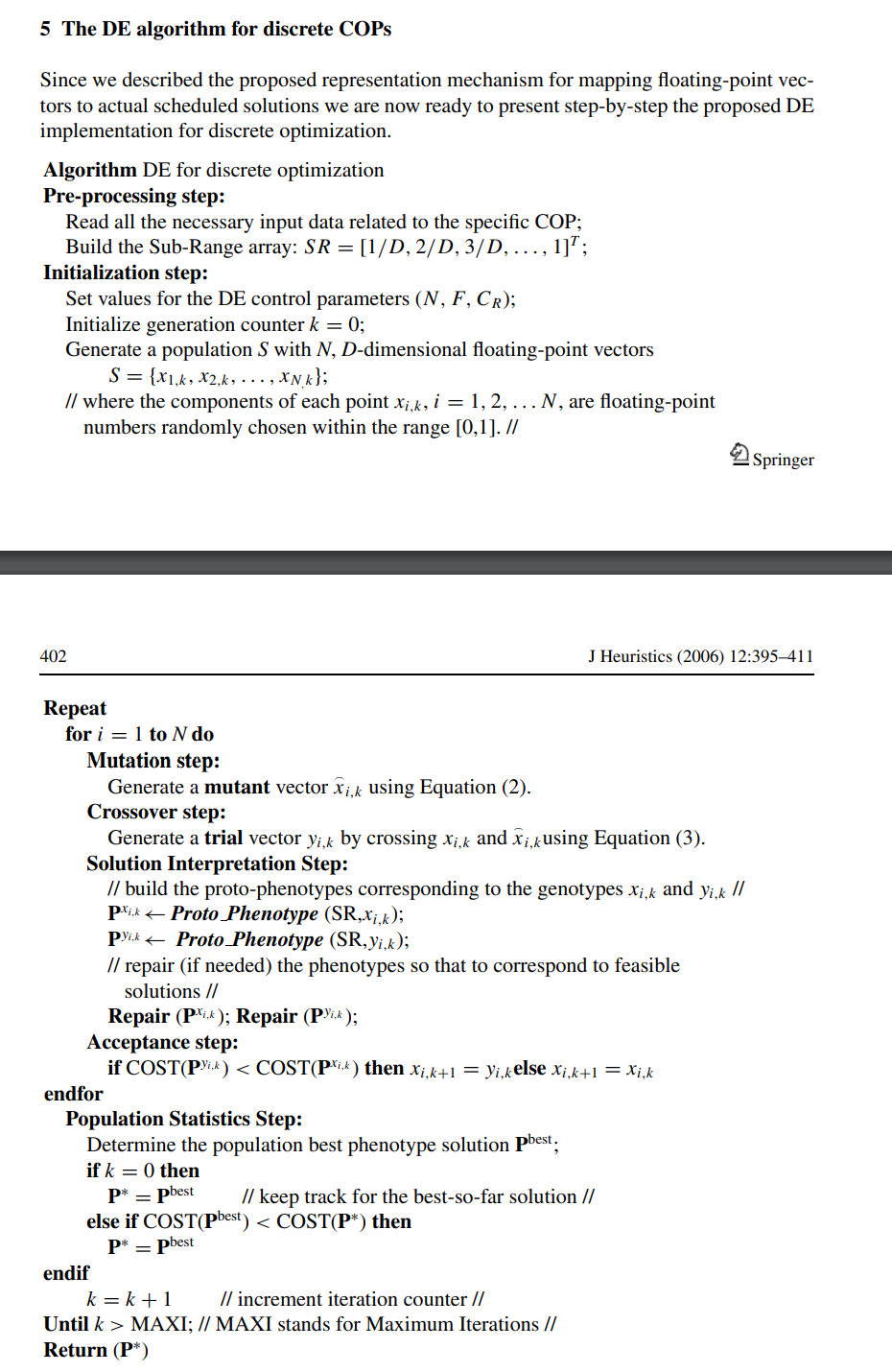
This discusses a basic idea of a differential evolution

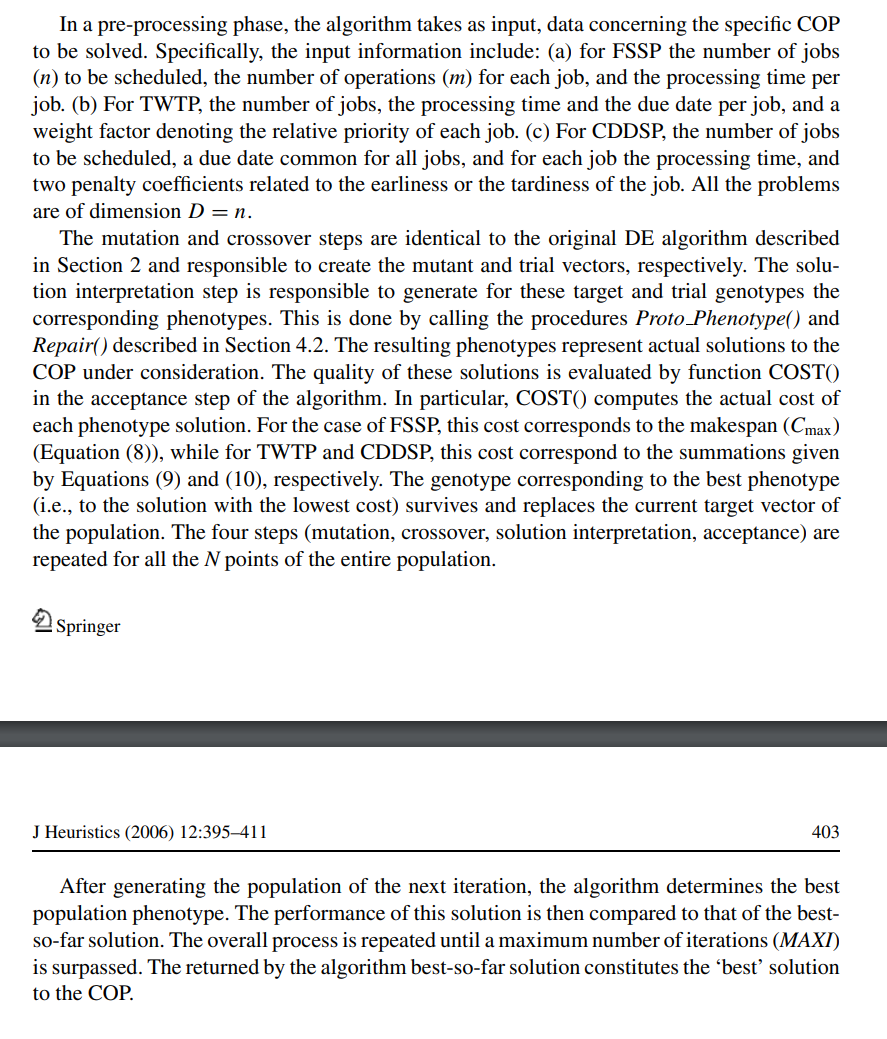
Strategy.

From the following paper









This explains a differential evolution approach using a proto phenotype that is being generated.

From the following paper



APPROACH/ALGORITHIMS

First we start by defining our constraints

1. Resources must not overlap in time:
   * No professor can hold two classes at the same time
   * No student group can attend two classes at the same time
   * No classroom can host to classes at the same time
   * Note: the term "same time" does not only mean the starting time of a class, but what also must be taken into account is the length of a class. If a resources is taken at time T1 and the class lasts for t, then the resource can be taken again only at time T2.

The constraints must be met (hard constraints)

2. Additional possible soft constraints

* Minimize total idleness for each group (pauses between classes)
* Minimize total idleness for each professor (pauses between classes)
* Provide one free hour a week with no classes, for a professors union meeting
* Minimize daily load for professors and groups (less than 6 hours of class a day)

Classes:

1. Data (contains data and some preformatting functions)
2. Schedule (to be populated with the data of each generation by the program)
3. Population
4. Course
5. Instructor
6. Classroom
7. ClassTime
8. Department
9. Class

Algorithms:

* Differential algorithm:

1. Data formatting and discerning algorithm
2. Cross over algorithm
3. Mutation algorithm
4. Fitness calculation algorithm
5. An algorithm to select the optimum solution(Solution Selection algorithm)

Use Case Diagram:

Diagram

Description automatically generated

Diagram

Description automatically generatedBlock diagram:

Experiments & Results (Phase 2):

Input Data:

A picture containing table

Description automatically generated

Table

Description automatically generated

Calendar

Description automatically generated with medium confidenceTable

Description automatically generatedProcessing:

Table

Description automatically generatedOutput:

Analysis, Discussion, and Future Work (Phase 2)

Analysis of the results, what are the insights?

1. Select four parents (p1,p2,p3,p4)
2. Calculate the difference vector between two parents:

p1- p2

1. Add the difference to the third parent vector with weight F=0.5: p3 + F( p1- p2)
2. Crossover between the new vector and fourth parent with gene selection probability “crossover rate” CR=0.5:
   1. If ( Math.random() > CR ) xi = xi(p4)
   2. else xi = xi( p3 + F ( p1- p2) )
3. Compare the new child with fourth parent (p4, the more fit will reach the next generation.

What are the advantages / disadvantages?

* Advantage:
* finding the true global minimum of a multi modal search space regardless of the initial parameter values
* fast convergence
* using a few controls parameters
* DE algorithm which has been proposed particularly for numeric optimization problems is a population-based algorithm like genetic algorithms using the similar operators; crossover, mutation and selection.
* No derivatives are used.
* A population of NP solution vectors are successively updated by addition, subtraction, and component swapping, until the population converges, hopefully to the optimum.
* A simple and apparently very reliable method.
* Disadvantage:
  + Evolution has no disadvantages for a population, but the mechanisms by which it operates often create disadvantages for individuals in the population. Most genetic variations have no real effect at all. Some have mild to huge disadvantages to individuals, and a very small percentage create advantages (in the context of their current environment).

Sometimes what used to be an advantage in a previous environment is a large disadvantage when the environment changes.

Why did the algorithm behave in such a way?

The algorithm searches the design space by maintaining a population of candidate solutions (individuals) and creating new solutions by combining existing ones according to a specific process. The candidates with the best objective values are kept in the next iteration of the algorithm in a manner that the new objective value of an individual is improved forming consequently part of the population, otherwise the new objective value is discarded. The process repeats itself until a given termination criterion is satisfied.

DE performs well for certain situations because the vectors can be considered to form a "cloud" that explores the high value areas of the solution space quite effectively. It's pretty closely related to particle swarm optimization in some senses.

what might be the future modifications you’d like to try when solving this problem?

To solving complex optimization problems. The proposed algorithm uses fuzzy logic inference system to dynamically tune the mutation factor of DE and improve its exploration and exploitation. In this way, two factors, named, the number of generation and population diversity are considered as inputs and, one factor, named, the mutation factor as output of the fuzzy logic inference system. The performance of the suggested approach has been tested firstly by using some popular single objective test functions. It has been shown that the proposed method finds better solutions than the classical differential evolution and also the convergence rate of that is really fast. Secondly, a five degree of freedom vehicle vibration model is chosen to be optimally designed by the aforesaid proposed approach. Comparison of the obtained results with those in the literature demonstrates the superiority of the results of this work.