Analysis of the Generation of Explanations for Self-assessment Exercises on Algorithm Schemes and Data Structures

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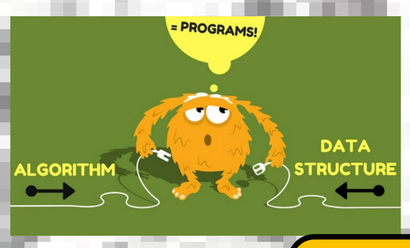
INEDA Innovation group

Goals:

- Improving the students experience and results with a self-assessment tool by including formative feedback
- Applying AI and Natural Language Processing techniques to automate the generation of feedback as much as possible
- Analysing the most appropriate kind of feedback for each kind of question

The subject (UNED, Spain, Computer Science): Advanced Data Structures and Algorithmic Schemes



Data Structures: Ways of organizing information to facilitate the development of algorithms or programs.

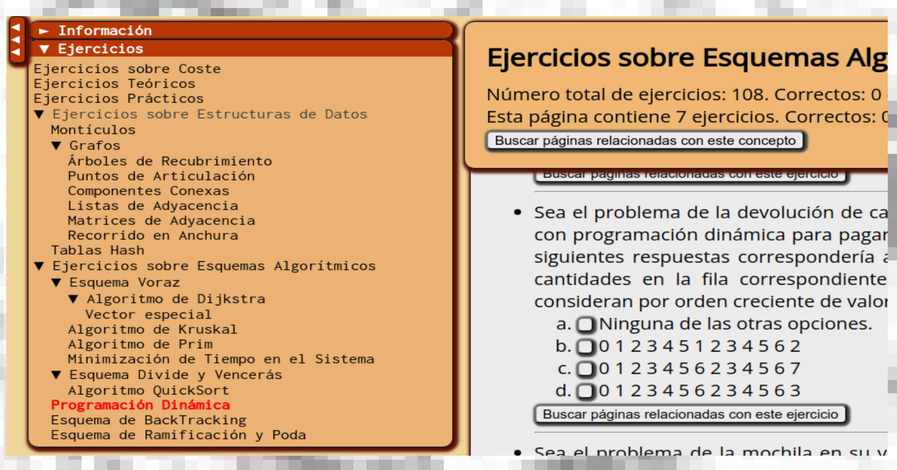
- STACKS
- QUEUES
- GRAPHS, etc.

Algorithmic schemes: Strategies for approaching problems

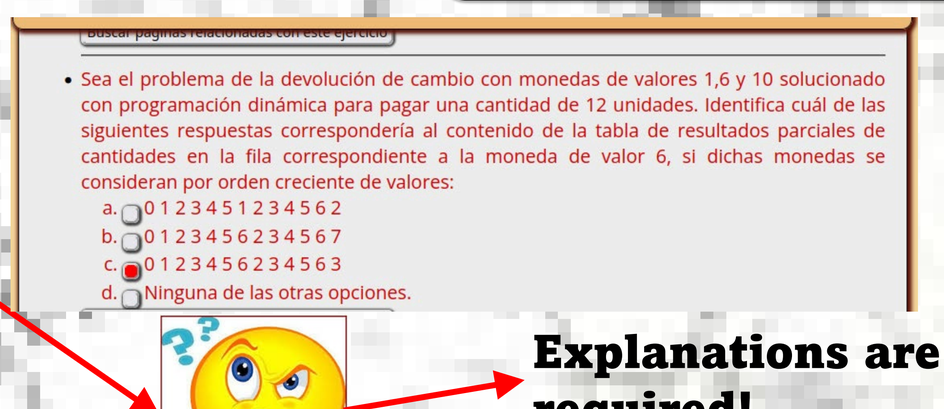
- GREEDY STRATEGY
- DIVIDE AND CONQUER
- BACKTRACKING, etc.

Algorithms for important problems:
- SEARCHES
- SHORTEST PATH between two points, etc.

Self-assessment tool:



Wrong!

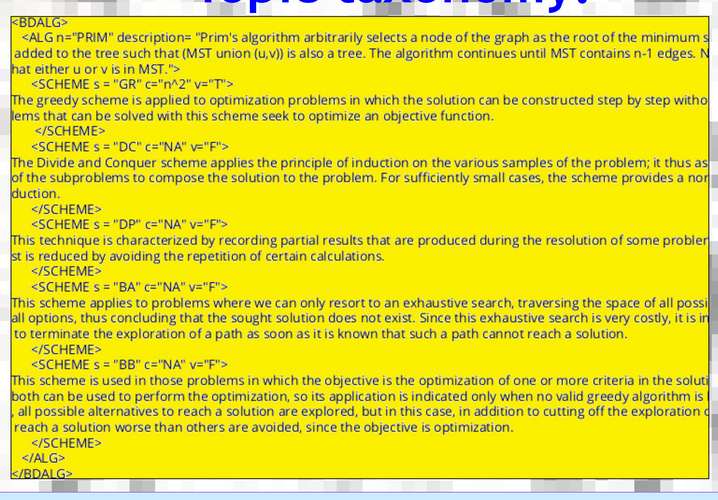


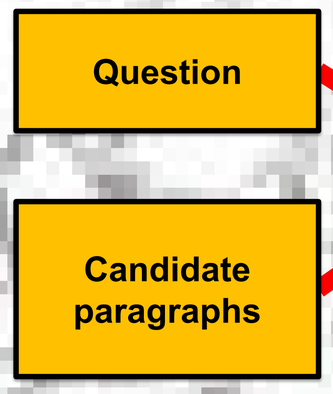
Explanations are required!

Why?

Techniques:

Topic taxonomy: + Semantic similarity techniques (AI and NLP):





Types of theoretical questions:

- SPECIFIC SUBJECT: Different claims about a specific topic.
- SCHEME SELECTION: Questions about the most appropriate algorithmic scheme for having less temporal or spatial cost to solve a problem
- COST: Questions about algorithmic cost associated with different data structures or algorithms.

SPECIFIC SUBJECT: Questions that present different claims about a specific topic. For example, the following question states several possibilities related to hash tables:

With respect to collision resolution (
(a) The linear probing allows greate
b) If the load factor is 1, it can be s
c) Open hashing includes a resolut
d) None of the above is correct. (T)

SCHEME SELECTION: Questions about the most appropriate algorithmic scheme for having less temporal or spatial cost to solve a problem. For example, the greedy scheme is the most efficient for solving problems in which the objective is to optimize some parameter. However, it is not always possible to apply it. To solve this type of problems it is necessary to make an analysis of how each algorithmic scheme could be applied to the problem, if it would be correct, and what would be the associated cost. An example of such a question is shown below.

Two pirates intend to share equally the treasure accumulated in their years of pillaging. Each stolen object has a value. As both pirates have their preferences for some objects, before deciding which ones to keep they want to know all the possible ways to divide the treasure in two equal parts. Indicate which of the following schemes would be the most suitable for designing an algorithm to do that task.

a) Greedy algorithm.
b) Backtracking.(T)
c) Branch and bound.
d) Divide and conquer.

COST: Questions about algorithmic cost associated with different data structures or algorithms. An example of such a question is shown below.

In the graph coloring problem with n nodes using m colors such that no two adjacent vertices have the same color, an adjusted upper bound to the cost of finding a solution using a suitable scheme is in the order of:

a) O(n^2)
b) O(n m^n) (T)
c) O(m log n)
d) O(n^m)

Results:

TYPE OF QUESTION	TECHNIQUE	CORRECT FEEDBACK	SIMILARITY(BEST)
SPECIFIC SUBJECT	SEMANTIC SIMILARITY	✓	0.7278
SCHEME SELECTION	TOPIC TAXONOMY+ SEMANTIC SIMILARITY	✓	0.6401
COST	TOPIC TAXONOMY + SEMANTIC SIMILARITY	✓	0.8520

Example:

ITEM1: *With respect to the resolution of collisions in Hash functions, it can be stated that the linear path allows a greater dispersion of collisions than the quadratic path.*
SIM: 0.7278948426246643
FEEDBACK PARAGRAPH: *Quadratic probing: in the case of the linear probing, the probability of new collisions is quite high for certain key patterns. There is another method based on a quadratic expression based on the function that allows greater dispersion of collisions through the table, while providing a complete traversal of the table.*

Conclusions

- Semantic similarity techniques based on transformers automatically select from a book on the subject the most appropriate paragraphs to be presented as feedback for each question.
- Automatically generated feedback is highly correlated with the self-assessment question considered.

Future work

- Complete a taxonomy with the feedback corresponding to each self-assessment question.
- Consider other types of questions such as those of a practical nature.
- Refine the similarity models.