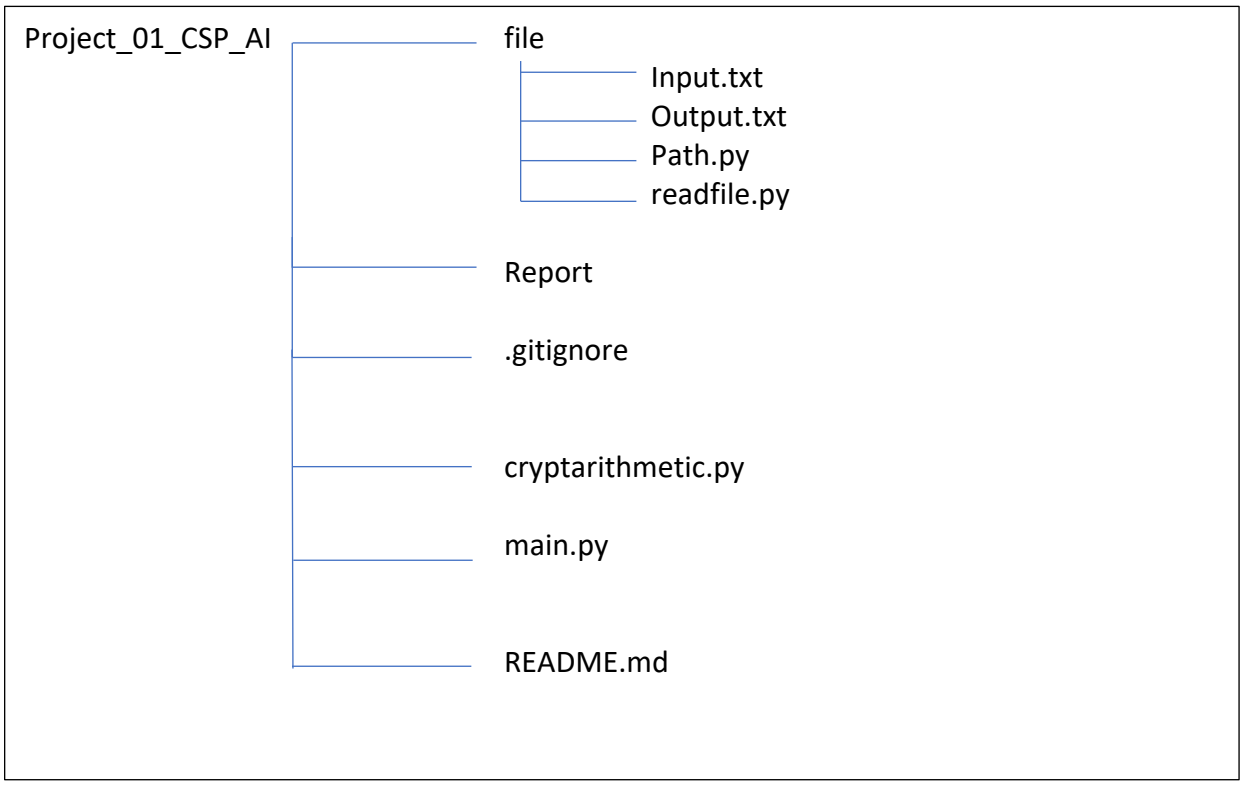
Report

1. Group student name

ID	Name
1651049	Chu Đức Khánh
1651009	Giảng Thanh Danh
1751062	Lê Quốc Anh Huy

2. Source code



2.1 Project Link: https://github.com/chukhanh/Project_01_CSP_AI
2.2 Language: Python
2.3 Explain about Source code
- 2.3.1 File : a place for input , output , import and read files
  - a. Input.txt: a place for user input a format
    Example: SEND + MORE == MONEY
  - b. Output.txt: a place for user sees the result.
  - c. Path.py: a function to import file input, output to different file or folder
  - d. Readfile.py: a function to read file input
- 2.3.2 Report: a place for my team writes report for project.

2.3.3 .gitignore: A file specifies intentionally untracked files that Git should ignore

2.3.4 Cryptarithmetic.py: A function to run follow Cryptarithmetic Problem in AI

2.3.5 Main.py: main of project

3. Libraries.
   - 3.1 The third-party regex module, which has an API compatible with the standard library "re" module, but offers additional functionality and a more thorough Unicode support.
   - 3.2 Math module
   - 3.3 z3-solver Library (To install from python: python3 -m pip install name_library): (Reference: https://ericpony.github.io/z3py-tutorial/guide-examples.htm)
     Z3 is a high performance theorem prover developed at Microsoft Research. Z3 is used in many applications such as: software/hardware verification and testing, constraint solving, analysis of hybrid systems, security, biology (in silico analysis), and geometrical problems

4. Assignment Plan Cryptarithmetic Problem

ID	1651009	1651049	1751062
Week 1	Solve Level 1	Research solution for level 2	Research solution for level 2
Week 2	Research solution for level 3	Solve Level 2	Research solution for level 3
Week 3	Research solution for level 4	Research solution for level 4	Solve level 3
Week 4	Research solution for level 4	Solve Level 4	Research solution for level 4

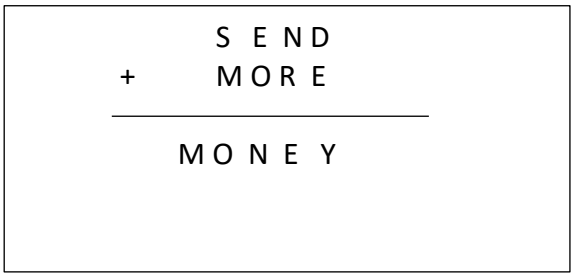
Estimates for each level (Each level tests more than 10 times from different math formulas):

- Level 1: 100% completion level, Time for results in about 1 seconds
- Level 2: 100% completion level, Time for results about 10 seconds
- Level 3: 100% completion level but time for results about 140 seconds
- Level 4: 100% completion level but The end result took too long. On average, printing out results takes nearly 20 minutes, even time can be up to 1 hour depending on the complexity of the given formula.

5. Describe the algorithm Verbal arithmetic

   According wikipedia, Verbal arithmetic, also known as alphametics, cryptarithmetic, cryptarithm or word addition, is a type of mathematical game consisting of a mathematical equation among unknown numbers, whose digits are represented by letters of the alphabet. The goal is to identify the value of each letter. The name can be extended to puzzles that use non-alphabetic symbols instead of letters.

Solving cryptarithms:



1. From column 5, **M = 1** since it is the only carry-over possible from the sum of two single digit numbers in column 4.
2. Since there is a carry in column 5, O must be less than or equal to M (from column 4). But O cannot be equal to M, so O is less than M. Therefore **O = 0**.
3. Since O is 1 less than M, S is either 8 or 9 depending on whether there is a carry in column 4. But if there were a carry in column 4, N would be less than or equal to O (from column 3). This is impossible since O = 0. Therefore there is no carry in column 3 and **S = 9**.
4. If there were no carry in column 3 then E = N, which is impossible. Therefore there is a carry and N = E + 1.
5. If there were no carry in column 2, then (N + R) mod 10 = E, and N = E + 1, so (E + 1 + R) mod 10 = E which means (1 + R) mod 10 = 0, so R = 9. But S = 9, so there must be a carry in column 2 so **R = 8**.
6. To produce a carry in column 2, we must have D + E = 10 + Y.
7. Y is at least 2 so D + E is at least 12.
8. The only two pairs of available numbers that sum to at least 12 are (5,7) and (6,7) so either E = 7 or D = 7.
9. Since N = E + 1, E can't be 7 because then N = 8 = R so **D = 7**.
10. E can't be 6 because then N = 7 = D so **E = 5** and **N = 6**.
11. D + E = 12 so **Y = 2**.

References:

1. https://en.wikipedia.org/wiki/Verbal_arithmetic