PATTERN RECOGNITION OF FINGERPRINT RIDGE LINES

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Subject & Aim

The problem is easy enough to describe, yet solving it is no small feat. It involves coming up with innovative methods to analyze and match fingerprints. The aim is to write a program which can match fingerprints from those in a database with a better efficiency, and in a minimal amount of time.

1. What's Original?

- I will be keeping the human nature of the problem at the heart of the mathematical reasoning.
- Many branches of mathematics, not just machine learning will come into play.
- I will analyze different computational strategies and compare them.
- With the above methods and numerical tools I can make my program run in optimal computational time.

2. What Strategy to Use?

I intend to compare the performance of different algorithms:

- Some are completely independent of input and the computations are optimal according to a criterion and determined solely by the computer.
- Some will use recent developments in areas of mathematics such as Topological Data Analysis which analyze the untapped mathematical structure of data.

I will compare these methods with the current standards, however it should be noted due to the nature of the work that all results I get will need to be make sure my algorithms are understandable enough to be used by fingerprint experts or in courts.

3. The Involved Data

Samples represent what the algorithm would consider to be complete data, in this case, the set of all possible fingerprints. The importance of data samples in machine learning is not to be underestimated. It may be the source of a bias and impair to the program's performances, to overcome this issue:

- It is necessary to have a data sample which is representative of what experts have to deal with.
- Resorting to computational fingerprint generation may be an option.
- It is vital to make sure that the experts are in accordance with the results.

4. A Very General Formal Setting

The main setting of my study relies on the optimization of a function which depends on a random variable, namely the sample S.

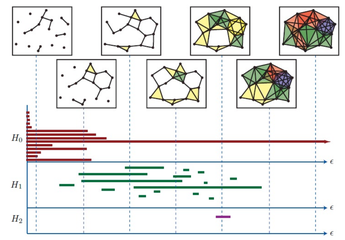
$$\phi^* = \max_{\phi \in T} \mathbb{E}[J \circ \phi(S)]$$

We judge the result of an action which depends on a random variable, in our case this is the fingerprint we have to match, and search the optimal procedure which maximizes our expectation of a result: a fingerprint match.
This setting can be generalized to be able to measure and deal with not only the expectation, i.e the average performance of the algorithm, but also the possibility of a bad performance, or its worst-case performances.

5. Topological Data Analysis

Topological data analysis is a relatively new area of pure-applied crossover mathematics. It will allow be to deal with both the mathematical and human nature of the problem:

- Topology aims at defining and characterizing geometries and shapes
- I can then run an experiment with human participants and run the data through topological tools.
- This may allow me to come up with a mathematical definition of patterns which is in accordance to that of human beings.



6. Effective Numerical Implementation

- I can make use of computation automatic differentiation and symbolic calculus to optimize my solutions to the problem.
- I could also make use of GPUs (graphics cards), which are particularly well-suited for image processing, and parallel computing in order to improve the computing speed.

References

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