Principal Points on the Study Regarding the Estimation of Flight Arrival Delays Through Deep Learning Models

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With the proposed work, the problem of estimating flight arrival delays is considered. The developed study proposes a methodology for automated forecasts of delays using available datasets involving flight operations and their characteristics.

More precisely, datasets comprised of time ordered information involving domestic flights in USA covering years from 2009 to 2018 are provided. Hence, for every considered flight, values for multiple involved characteristics or *features* are available such as the name of the operating airline, the related flight number, the origin and destination airports, the departure and arrival time etc.

Business Interest

Any tools that can enhance Flight Movement Intelligence can be invaluable for Airline and Airport Operations.

Imagine the reallocation of assets (Gates, Parking, Runways, hangars, personnel, passengers)

Energy savings from fuel and reduced carbon footprints

Better Facilities Management

Better Passenger/Package rerouting

Better ATC (Air Traffic Control) routing

Better Balance in Operations

All possible with negligible energy consumption!

Scientific Interest

A study on a spatiotemporal problem regarding the prediction of flight arrival delays through Deep Neural Networks (DNN) is presented.

Various *adjustable DNN models*, with or without memory regarding past information, are proposed each one appraised according to various desired metrics. Each *adequately adjusted* model, fed by a dataset, proposes a mechanism (mapping) associating each input entry (information on a particular flight) to an output value (related flight arrival delay). The more efficient this mapping is the more reliable are the estimations resulting from the model when the considered mapping is applied to new data provided to the model.

Regarding the proposed work among others two major questions appear:

- is Artificial Intelligence really advantageous?
- why employment of *DNN* is decided instead of a different Artificial Intelligence approach ?
- why *adjustable DNN models* are proposed ?
- what is the utility of the suggested software ?
- how the problem of estimating flight delays is addressed ? Different viewpoint appeals do exist?

During this work a *baseline* model is conceived estimating delays without the involvement of any Artificial Intelligence (AI) technique. Any of the proposed models involving AI, even if non optimized architectures are considered, provide improved results.

Regarding the choice of the employed AI approach, the same problem could have been handled by a Machine Learning (ML) technique searching mappings within a *predefined space* of possible solutions. Contrary to ML, DNN models progressively create spaces of increasing complexity within which potential solutions are searched while these spaces are in accordance with each other. That is, for a model having created m sequential spaces of possible solutions, the characteristics of space n ($n < m$) depend upon the characteristics of spaces $n-1$ and $n+1$ ($n+1 \leq m$). Due to this property, DNN models are more performant than ML techniques especially when complex problems are involved.

An optimized model is an *adequately adjusted* model. That is, a model for which efficient values for a specific type of parameters are found, the so called *hyperparameters* precisely defining the model architecture (e.g. determining the number of coordinated consecutive spaces of possible solutions to create). An *adequately adjusted* model can then provide reliable estimations for the future flight delays.

However, a manual, empirical model adjustment, blindly testing hazardous, arbitrary hyperparameter values is a hard task often resulting to suboptimal solutions.

In addition to the introduced *adjustable models*, a decision tool systematically automatizing the model adjustment through a set of processes is also developed as part this work. For each considered set of possible configuration values, the involved model is appraised. Among the created models the *best* models are returned. The inferences of these best models as well the related evaluation metrics are also provided. Furthermore, new DNN models can be conceived and easily experimented within the provided software. This is one of the primary purposes of the software, easily adjust and appraise a DNN model providing the best version of it.

During this study, two distinct approaches related to the data exploration are presented.

In the first approach, each model proposes a mapping between data inputs involving all available origin airports (departing locations of flights) and outputs estimated values for future arrival delays of flights having departed any origin airport. More precisely, for this case the hypothesis of a potential kind of dependence among at least some data entries each is considered.

According to the second approach, a distinct study is provided per origin airport. In this case, the model tries to forecast arrival delays of flights having departed from

the same airport (and potentially arriving at distinct or same destinations). Thus, the mappings proposed by any model are using data entries having the same value for feature "ORIGIN" and forecast arrival delays for flights having departed the same airport. The hypothesis of independence between the data entries related to distinct values of feature "ORIGIN' is now made. Consequently, the initial dataset is decomposed into subsets each one involving a specific value of feature "ORIGIN" (a specific departing airport). Each model, after creating as many mappings as the distinct "ORIGIN' airports, proceeds to forecasts of the arrival delays for flights departed the involved airport.

Each proposed model, is experimented for limited sets of possible (desired) values regarding the involved hyperparameters, fed only by data of year 2009, due to limited computer resources and time constraints. Consequently, no comparative study regarding the performance of each model can be provided as no definite conclusions regarding the model appraisal can be drawn. However, the proposed methodology remains valid for any dataset and of any size.

Under the aspect of a long term vision, aiming at task automation for efficient estimations on timeseries problems, proposals for further development of this work are included within the related report presenting the different stages of the introduced study.