**Some notes from Thieu Nguyen**

0) My recommendation is that.

+ Our proposed models include: 3 state-of-the-art meta-heuristics (2019) – Multi-Layer Perceptron

+ The most comprehensive and wide-range comparison ever: 14 models

+ Traditional models:

+ MLP

+ RNN (One of the most famous model for time-series)

+ Hybrid models: (Metaheuristics + MLP)

+ Evolutionary-based metaheuristics:

+ GA (Genetic Algorithm)

+ DE (Differential Evolution)

+ FPA (Flower Pollination Algorithm)

+ Swarm-based metaheuristics

+ PSO (Particle Swarm Optimization)

+ WOA (Whale Optimization algorithm)

+ GWO (Grey Wolf Optimization algorithm)

+ SSA (2020 - A novel swarm intelligence optimization approach: sparrow search algorithm)

+ Physics-based metaheuristics:

+ WDO (Wind Driven Optimization – too old - 2010)

+ MVO (Multi-Verse Optimization - old, 2016)

**+ EO (Equilibrium optimizer: A novel optimization algorithm - No one use it yet, 2019)**

**+ NRO (Nuclear Reaction Optimization: A novel and powerful physics-based algorithm for global optimization)**

**+ HGSO (Henry gas solubility optimization: A novel physics-based algorithm, 2019)**

1) I used google color design for the stability figures. You can use the Hex Code below to draw your figures also (This will make the papers clearly when reader looking at visualization pictures.

(*https://material.io/design/color/the-color-system.html#tools-for-picking-colors*)

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Model | Name | Hex Code |
| Traditional | MLP | Blue | #1E88E5 |
| RNN | Amber | #FFC107 |
| Evolutionary-MLP | GA-MLP | Pink | #D81B60 |
| DE-MLP | Green | #43A047 |
| FPA-MLP | Yellow | #FDD835 |
| Swarm-MLP | PSO-MLP | Cyan | #00ACC1 |
| WOA-MLP | Brown | #6D4C41 |
| GWO-MLP | Lime | #C0CA33 |
| SSA-MLP | Indigo | #3949AB |
| Physics-MLP | WDO-MLP | Gray | #757575 |
| MVO-MLP | Teal | #00897B |
| EO-MLP | Orange | #FB8C00 |
| NRO-MLP | Purple | #8E24AA |
| HGSO-MLP | Red | #E53935 |

2) The indicators performance included:

|  |  |  |  |
| --- | --- | --- | --- |
| **Short name** | **Full name** | **Equations** | **Meaning** |
| RE | Relative Error |  | Smaller is better |
| RMSE | Root Mean Square Error |  | Smaller is better |
| MAE | Mean Absolute Error |  | Smaller is better |
| MAPE | Mean absolute percentage error |  | Smaller is better |
| WI | Willmott Index |  | Bigger is better (Maximum is 1) |
| R | Pearson’s correlation coefficient |  | Bigger is better (Maximum is 1) |
| CI | Confidence Index (Performance Index) | WI \* R | Bigger is better (Maximum is 1) |

3) Confidence Index (Performance of models based on CI)

|  |  |
| --- | --- |
| **Confidence Value** | **Performance** |
| > 0.85 | Excellent |
| 0.76 – 0.85 | Very good |
| 0.66 – 0.75 | Good |
| 0.61 – 0.65 | Satisfactory |
| 0.51 – 0.60 | Poor |
| 0.41 – 0.50 | Bad |
| <= 0.4 | Very Bad |

4) References for your knowledge about indicators:

WI, R, CI : <https://www.researchgate.net/publication/319699360_Reference_evapotranspiration_for_Londrina_Parana_Brazil_performance_of_different_estimation_methods>

RMSE, MAE, MAPE:

<https://medium.com/analytics-vidhya/forecast-kpi-rmse-mae-mape-bias-cdc5703d242d>

**Experiment Results and Discussion**

The table below is the Mean results of 10 run times for each models.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| MEAN Table | | | | | | | |
| Type | Model | RMSE | MAE | MAPE | WI | R | CI |
| Traditional Nets | MLP | 2.878 | 1.656 | 20.869 | 0.933 | 0.886 | 0.827 |
| RNN | 2.523 | 1.498 | 21.033 | 0.942 | 0.912 | 0.863 |
| Evolutionary-MLP | GA-MLP | 2.932 | 1.699 | 20.852 | 0.917 | 0.885 | 0.811 |
| DE-MLP | 2.563 | 1.63 | 22.978 | 0.945 | 0.912 | 0.862 |
| FPA-MLP | 2.651 | 1.599 | 20.951 | 0.938 | 0.902 | 0.847 |
| Swarm-MLP | PSO-MLP | 2.557 | 1.516 | 19.853 | 0.945 | 0.908 | 0.858 |
| WOA-MLP | 2.634 | 1.562 | 20.092 | 0.941 | 0.903 | 0.849 |
| GWO-MLP | 2.777 | 1.69 | 22.266 | 0.935 | 0.891 | 0.833 |
| SSA-MLP | 2.792 | 1.683 | 22.251 | 0.925 | 0.892 | 0.826 |
| Physics-MLP | WDO-MLP | 2.647 | 1.567 | 20.24 | 0.939 | 0.9 | 0.845 |
| MVO-MLP | 2.521 | 1.497 | 19.752 | 0.941 | 0.909 | 0.855 |
| EO-MLP | 2.498 | 1.514 | 19.913 | 0.947 | 0.911 | 0.863 |
| NRO-MLP | 2.489 | 1.484 | 18.673 | 0.951 | 0.914 | 0.869 |
| HGSO-MLP | 2.674 | 1.623 | 21.583 | 0.938 | 0.902 | 0.847 |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| STD Table | | | | | | | |
| Type | Model | RMSE | MAE | MAPE | WI | R | CI |
| Traditional Nets | MLP | 0.2211 | 0.0969 | 1.0655 | 0.0117 | 0.0165 | 0.0255 |
| RNN | 0.0676 | 0.044 | 0.9339 | 0.0036 | 0.0047 | 0.0072 |
| Evolutionary-MLP | GA-MLP | 0.2705 | 0.0949 | 1.702 | 0.0216 | 0.0217 | 0.0337 |
| DE-MLP | 0.1851 | 0.1467 | 2.8157 | 0.0052 | 0.0048 | 0.0085 |
| FPA-MLP | 0.128 | 0.0701 | 1.9193 | 0.0111 | 0.01 | 0.0184 |
| Swarm-MLP | PSO-MLP | 0.1339 | 0.0838 | 2.2318 | 0.0047 | 0.006 | 0.0089 |
| WOA-MLP | 0.2736 | 0.1307 | 1.2065 | 0.0182 | 0.0193 | 0.0336 |
| GWO-MLP | 0.1377 | 0.1204 | 2.7906 | 0.0081 | 0.0094 | 0.0156 |
| SSA-MLP | 0.2662 | 0.1492 | 3.0558 | 0.0197 | 0.0191 | 0.0338 |
| Physics-MLP | WDO-MLP | 0.2104 | 0.1197 | 1.3918 | 0.0097 | 0.012 | 0.0194 |
| MVO-MLP | 0.0894 | 0.048 | 1.7342 | 0.0074 | 0.0055 | 0.01 |
| EO-MLP | 0.0651 | 0.0563 | 1.203 | 0.0042 | 0.0045 | 0.007 |
| NRO-MLP | 0.1437 | 0.1054 | 1.4079 | 0.0043 | 0.0062 | 0.0097 |
| HGSO-MLP | 0.1688 | 0.1156 | 2.776 | 0.0121 | 0.0079 | 0.0165 |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| Coefficient of variation (CV) Table | | | | | | | |
| Type | Model | RMSE | MAE | MAPE | WI | R | CI |
| Traditional Nets | MLP | 0.0768 | 0.0586 | 0.0511 | 0.0125 | 0.0186 | 0.0308 |
| RNN | 0.0268 | 0.0294 | 0.0444 | 0.0038 | 0.0051 | 0.0083 |
| Evolutionary-MLP | GA-MLP | 0.0923 | 0.0559 | 0.0816 | 0.0235 | 0.0245 | 0.0416 |
| DE-MLP | 0.0722 | 0.09 | 0.1225 | 0.0055 | 0.0052 | 0.0098 |
| FPA-MLP | 0.0483 | 0.0439 | 0.0916 | 0.0118 | 0.0111 | 0.0217 |
| Swarm-MLP | PSO-MLP | 0.0524 | 0.0553 | 0.1124 | 0.005 | 0.0066 | 0.0104 |
| WOA-MLP | 0.1039 | 0.0837 | 0.06 | 0.0193 | 0.0214 | 0.0396 |
| GWO-MLP | 0.0496 | 0.0712 | 0.1253 | 0.0087 | 0.0106 | 0.0188 |
| SSA-MLP | 0.0954 | 0.0887 | 0.1373 | 0.0213 | 0.0214 | 0.0409 |
| Physics-MLP | WDO-MLP | 0.0795 | 0.0763 | 0.0688 | 0.0103 | 0.0133 | 0.023 |
| MVO-MLP | 0.0355 | 0.0321 | 0.0878 | 0.0079 | 0.006 | 0.0117 |
| EO-MLP | 0.0261 | 0.0372 | 0.0604 | 0.0045 | 0.005 | 0.0081 |
| NRO-MLP | 0.0577 | 0.071 | 0.0754 | 0.0045 | 0.0068 | 0.0112 |
| HGSO-MLP | 0.0631 | 0.0712 | 0.1286 | 0.0129 | 0.0087 | 0.0195 |

**6 stability figures corresponding with 6 metrics showed below:**

A picture containing table, sitting

Description automatically generated

A picture containing table, sitting

Description automatically generated

A picture containing indoor, table, sitting

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A screenshot of a cell phone

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