***PAPER 1: HYBRID MLP***

***# Traditional*1.** MLP  
**2.** RNN   
**3.** LSTM   
  
***# Evolutionary***   
**1.** GA-MLP  
**2.** DE-MLP  
  
***# Swarm***   
**1.** PSO-MLP  
**2.** WOA-MLP  
  
***# Physics (Our proposed)*1. Wind Driven Optimization (WDO) - 2013 - WDO- MLP  
2. Multi-Verse Optimizer (MVO) - 2016 - MVO- MLP  
2. Equilibrium Optimizer (EO) - 2019 - EO- MLP**

***PAPER 2: HYBRID LSTM***

***# Traditional*1.** MLP  
**2.** RNN   
**3.** LSTM   
  
***# Evolutionary*1.** GA-LSTM   
**2.** DE-LSTM  
  
***# Swarm*1.** PSO-LSTM  
**2.** WOA-LSTM (Whale)  
  
***# Physics (Our proposed)*1. Wind Driven Optimization (WDO) - 2013 - WDO-LSTM   
2. Multi-Verse Optimizer (MVO) - 2016 - MVO-LSTM  
2. Equilibrium Optimizer (EO) - 2019 - EO-LSTM**

1. Nuclear Reaction Optimization (NRO) - 2019 - NRO-LSTM
2. Henry Gas Solubility Optimization (HGSO) - 2019 - HGSO-LSTM
3. Atom Search Optimization (ASO) - 2019 - ASO-LSTM

**Paper 1: Hybrid MLP**

**Table 1: Bảng kết quả cho bộ dữ liệu daily rainfall**

* 3 model cuối là của mình đề xuất: WDO-MLP, MVO-MLP, EO-MLP
* Mới chạy them 3 model đề xuất nữa, vậy là có 6 model đề xuất.
* Sẽ lấy cái nào tốt nhất trong đống đó.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **EV** | | | **RMSE** | | | **MAE** | | |
|  | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** |
| MLP | 0.278 | **0.001** | **0.005** | 12.676 | 0.035 | 0.003 | 7.89 | 0.153 | 0.019 |
| RNN | 0.264 | 0.002 | 0.008 | 12.791 | **0.018** | **0.001** | 7.969 | 0.069 | 0.009 |
| LSTM | 0.266 | 0.003 | 0.011 | 12.771 | 0.032 | 0.002 | 7.952 | 0.08 | 0.01 |
| GA-MLP | 0.277 | 0.002 | 0.008 | 12.678 | 0.023 | 0.002 | 7.832 | 0.112 | 0.014 |
| DE-MLP | 0.197 | 0.051 | 0.26 | 13.741 | 0.373 | 0.027 | 8.317 | 0.668 | 0.08 |
| PSO-MLP | 0.27 | 0.01 | 0.038 | 12.741 | 0.092 | 0.007 | 7.889 | 0.048 | 0.006 |
| WOA—MLP | 0.238 | 0.061 | 0.256 | 13.019 | 0.509 | 0.039 | 8.084 | 0.369 | 0.046 |
| **WDO-MLP** | 0.274 | 0.004 | 0.015 | 12.704 | 0.044 | 0.003 | 7.925 | 0.12 | 0.015 |
| **MVO-MLP** | 0.265 | 0.016 | 0.059 | 12.78 | 0.134 | 0.011 | 7.867 | 0.051 | 0.006 |
| **EO-MLP** | 0.268 | 0.006 | 0.021 | 12.751 | 0.051 | 0.004 | 7.848 | **0.028** | **0.004** |
| **NRO-MLP** | **0.279** | 0.007 | 0.024 | **12.6** | 0.054 | 0.004 | **7.826** | 0.05 | 0.006 |
| **HGSO-MLP** | 0.257 | 0.017 | 0.067 | 12.882 | 0.195 | 0.015 | 8.006 | 0.445 | 0.056 |
| **ASO-MLP** | 0.206 | 0.019 | 0.092 | 13.459 | 0.221 | 0.016 | 8.887 | 0.533 | 0.06 |

**Table 2: Bảng kết quả cho bộ dữ liệu weekly rainfall**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **EV** | | | **RMSE** | | | **MAE** | | |
|  | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** |
| MLP | 0.211 | **0.005** | 0.203 | 7.758 | 0.062 | 0.008 | 5.63 | 0.140 | 0.038 |
| RNN | 0.08 | 0.008 | 0.103 | 8.446 | 0.074 | 0.009 | 6.315 | 0.138 | 0.022 |
| LSTM | 0.082 | 0.009 | 0.104 | 8.391 | 0.066 | 0.008 | 6.205 | 0.109 | 0.018 |
| GA-MLP | **0.221** | 0.007 | 0.031 | 7.714 | 0.078 | 0.01 | 5.609 | 0.139 | 0.025 |
| DE-MLP | 0.12 | 0.08 | 0.666 | 8.134 | 0.671 | 0.082 | 5.615 | 0.985 | 0.175 |
| PSO-MLP | 0.198 | 0.022 | 0.109 | 7.961 | 0.079 | 0.01 | **5.455** | 0.112 | 0.02 |
| WOA—MLP | 0.188 | 0.056 | 0.296 | 7.885 | 0.311 | 0.039 | 5.765 | 0.322 | 0.056 |
| **WDO-MLP** | 0.207 | 0.012 | 0.059 | 7.771 | **0.057** | **0.007** | 5.655 | 0.108 | 0.019 |
| **MVO-MLP** | 0.202 | 0.027 | 0.134 | **7.7** | 0.1 | 0.013 | 5.533 | **0.107** | **0.018** |
| **EO-MLP** | 0.185 | 0.068 | 0.365 | 7.89 | 0.369 | 0.047 | 5.768 | 0.365 | 0.063 |
| **NRO-MLP** | 0.201 | 0.016 | 0.08 | 7.722 | 0.103 | 0.013 | 5.51 | 0.108 | 0.02 |
| **HGSO-MLP** | 0.203 | 0.012 | **0.058** | 7.834 | 0.107 | 0.014 | 5.741 | 0.183 | 0.032 |
| **ASO-MLP** | 0.03 | 0.011 | 0.377 | 8.535 | 0.128 | 0.015 | 6.157 | 0.229 | 0.037 |

**Paper 2: Hybrid LSTM**

**Table 1: Bảng kết quả cho bộ dữ liệu daily rainfall**

* 6 model cuối là của mình đề xuất: WDO-LSTM, MVO-LSTM, EO-LSTM, NRO-LSTM, HGSO-LSTM, ASO-LSTM

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **EV** | | | **RMSE** | | | **MAE** | | |
|  | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** |
| MLP | **0.278** | **0.001** | 0.005 | **12.676** | 0.035 | 0.003 | 7.89 | 0.153 | 0.019 |
| RNN | 0.264 | 0.002 | 0.008 | 12.791 | 0.018 | **0.001** | 7.969 | 0.069 | 0.009 |
| LSTM | 0.266 | 0.003 | 0.011 | 12.771 | 0.032 | 0.002 | 7.952 | 0.08 | 0.01 |
| GA-LSTM | 0.277 | **0.001** | **0.004** | 12.679 | **0.017** | **0.001** | 7.86 | 0.068 | 0.009 |
| DE- LSTM | 0.264 | 0.011 | 0.04 | 12.807 | 0.132 | 0.01 | **7.78** | 0.409 | 0.053 |
| PSO- LSTM | 0.269 | 0.009 | 0.032 | 12.745 | 0.075 | 0.006 | 7.847 | 0.043 | 0.005 |
| WOA— LSTM | 0.261 | 0.009 | 0.034 | 12.818 | 0.077 | 0.006 | 7.894 | **0.019** | **0.002** |
| **WDO-LSTM** | 0.272 | 0.004 | 0.014 | 12.716 | 0.036 | 0.003 | 7.871 | 0.183 | 0.023 |
| **MVO- LSTM** | 0.262 | 0.007 | 0.025 | 12.81 | 0.071 | 0.006 | 7.896 | 0.123 | 0.016 |
| **EO- LSTM** | 0.266 | 0.006 | 0.022 | 12.768 | 0.054 | 0.004 | 7.849 | 0.028 | 0.004 |
| **NRO- LSTM** | 0.271 | 0.004 | 0.015 | 12.725 | 0.039 | 0.003 | 7.826 | 0.065 | 0.008 |
| **HGSO- LSTM** | 0.274 | 0.004 | 0.014 | 12.745 | 0.084 | 0.007 | 7.92 | 0.39 | 0.049 |
| **ASO- LSTM** | 0.146 | 0.116 | 0.798 | 14.468 | 1.005 | 0.069 | 9.74 | 1.309 | 0.134 |

**Table 2: Bảng kết quả cho bộ dữ liệu weekly rainfall**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **EV** | | | **RMSE** | | | **MAE** | | |
|  | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** | **Mean** | **Std** | **Cv** |
| MLP | 0.211 | **0.005** | **0.023** | 7.758 | 0.062 | 0.008 | 5.63 | 0.104 | 0.018 |
| RNN | 0.08 | 0.008 | 0.103 | 8.446 | 0.074 | 0.009 | 6.315 | 0.138 | 0.022 |
| LSTM | 0.082 | 0.009 | 0.104 | 8.391 | 0.066 | 0.008 | 6.205 | 0.109 | 0.018 |
| GA-LSTM | 0.215 | 0.007 | 0.031 | 7.701 | 0.071 | 0.009 | 5.553 | 0.136 | 0.025 |
| DE- LSTM | 0.207 | 0.025 | 0.12 | 7.783 | 0.219 | 0.028 | 5.629 | 0.309 | 0.055 |
| PSO- LSTM | 0.207 | 0.024 | 0.117 | 7.66 | 0.095 | 0.012 | **5.458** | **0.086** | **0.016** |
| WOA— LSTM | 0.209 | 0.012 | 0.057 | 7.733 | 0.076 | 0.01 | 5.54 | 0.119 | 0.021 |
| **WDO-LSTM** | 0.196 | 0.01 | 0.053 | 7.858 | 0.09 | 0.011 | 5.77 | 0.16 | 0.028 |
| **MVO- LSTM** | 0.203 | 0.018 | 0.089 | 7.679 | 0.066 | 0.009 | 5.489 | 0.077 | 0.014 |
| **EO- LSTM** | 0.17 | 0.022 | 0.131 | 7.765 | 0.091 | 0.012 | 5.521 | 0.112 | 0.02 |
| **NRO- LSTM** | **0.22** | 0.009 | 0.04 | **7.657** | **0.053** | **0.007** | 5.488 | 0.097 | 0.018 |
| **HGSO- LSTM** | 0.206 | 0.022 | 0.109 | 7.912 | 0.329 | 0.042 | 5.86 | 0.534 | 0.091 |
| **ASO- LSTM** | 0.058 | 0.061 | 1.061 | 9.075 | 0.262 | 0.029 | 7.231 | 0.372 | 0.051 |