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Solar Power Forecasting Using Artificial Intelligence

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Abstract: *Analysingthe Output Power ofaSolar Photo- voltaic Systematthe design stage and atthe same time predictingtheperformanceofsolarPV Systemunder dif- ferentweatherconditionisaprimary worki.e.tobecar-riedoutbeforeanyinstallation.Thelevelofso- larPowerthat can begeneratedbyasolar photovoltaic system dependsupon theenvironmentinwhich itisop- eratedandtwoother important factorliketheamountof solarinsolationandtemperature.Asthesetwofactors*

$$I_{ph} = I_{ph,stc}\left(\frac{G}{G_{stc}}\right) + K_i(T - T_{stc}) \quad (1)$$

Apartfromongoing discussedforecastingmethods,some other statisticallyused method usually start withmathe- matical functionwhichdescribe thelinearandnonlinear relationshipbetweenthedatasetsandtheirbehaviourto the environmentalparameterwith an objective tomini- mizethevariationofmathematicalfunction.Inthiscase the analysistakes along time toanalysethe result and thereby making convergenceofthesystem optimizedpa- rameters.Thispaperpresentacomparativeanalysisofall theforecastingmethod mainly used byresearchersover pastdecade.Thepaperdescribesabouttheartificialintelli- gencebased extremum learningalgorithmforforecasting thesolarhiddennetwork suchasanalysingsomekindof weight tothehiddenlayerand arbitraryselectionofhid- denbiaswasselectedby applyingthegeneticalgorithmto themaster realtimedata which arecollected fromopen source data based onmeteorologicaldepartment.Differ- entsection ofthepaper includes theproposedideaisar- rangedinthefollowingmanner.1stsectiondescribesabout brief descriptionofforecastingfollowed by2ndsection which mainly deals withthemodellingofPVcellsalong withdifferentMPPTtechniquewithspecialfocusonincre- mentalconductancemethod.3rdand4thsectiondescribes aboutresultanalysisandcomparisonwithnewtechnique.
5thsection describes about theconclusionalongwithfu- turedevelopment.

2 PVModel

Themain aim ofsolar PVforecastingistoforecast the weatherconditionsuch as temperature,solar radiation Where Grepresentsthe solar radiation,G_{stc} repre- sentsthestandardsolarradiation,$I_{ph,stc}$ representsphoto generatedcurrentduring standardtemperaturecondition (STC),Tand T_{stc} temperatureand temperatureatSTCre- spectively.Similarlythemaximumpowergeneratedbythe solarPV[redacted]

$$P_V = A[\ 0.05(\quad)] \quad (2)$$

Wheretotalconversionefficiencyisrepresentedby This isfortheentire solarPVarray, totalareacovered bythe solar PVarray representedbyA(m^2).Solarinso- lencefallingonthearrayisrepresentedbyI(kw/m^2)and

representsthetotalambienttemperatureofPVarrayin (C).Therealtimemodelwhichwasdevelopedin MATLAB simulinkmodelconsist of72noofcellshaving totalmax- imumoutputpowerof300Wp(p_{max}). Maximumshortcir- cuitcurrent is.

(1) Intraday Forecasting

Inthecompetitiveenergymarket availabilityofelectrical energyatthepointofdemandisthemostchallengingjob. Intradayforecastingwhich isusually fromsomefewsec tominute could abletoensure theav

2

=

$$\sum_{i=1}^{n} |e_i| \qquad (5)$$

system selectionfortheelectricity market.

tivefunctionasshownbelow

$y=3.6169x^2+4077.3x\ \ 25301$ (14)

Theobjective functionasshown inequation14was de- rivedfromthePolynomialisationofTemperatureand AC output(kWh),whichisshowninFigure

Table1: Observed&CalculatedvalueofEnvironmental TemperatureandSolarPVOutput

Month	Month	ACSystemOutput (kWh)	ACSystem Output(kWh)-Calculated	Observed Temp.	Forecasted Temperature	Solar Radiation (kWh/m^2/day)
1	Jan	82257.875	81609.98438	26.53	26.77	4.2925396
2	Feb	100442.0313	99655.03125	30.97	30.91	5.67678547
3	Mar	135883.5938	134822.3594	34.81	37.95	6.68656969
4	Apr	142563.4375	141450.9688	39.92	40.28	6.84843159
5	May	145573.6094	144436.5625	39	40.23	6.48288298
6	Jun	125976.9844	124990.3047	32.34	37.9	5.53810167
7	Jul	119612.6172	118674.0938	31.28	32.85	4.99226809
8	Aug	114054.0469	113159.0781	32.68	35.56	4.94502401
9	Sep	113528.625	112638.5859	35.76	34.24	5.49704838
10	Oct	110454.2891	109588.3906	31.37	33.34	5.54661322
11	Nov	90045.02344	89337.64844	28.1	29.08	4.85409641
12	Dec	80529.05469	79894.44531	33.71	35.03	4.25716782

Table2:MSEandtheHiddenlayerdetails

NumberofNeurons FirstHiddenLayer	HiddenLayer	MeanSquareError Train	Validation	Test
10	10	0.0071	0.0198	0.0189
10	15	0.0082	0.0174	0.0192
10	20	0.0001	0.0146	0.0120
10	25	0.0009	0.0180	0.0173
10	30	0.0089	0.0191	0.0175
20	10	0.0023	0.0131	0.0117
20	15	0.0072	0.0171	0.0145
20	20	0.0018	0.0176	0.0169
20	25	0.0010	0.0195	0.0202
20	30	0.0017	0.0216	0.0185

Table3: RegressionStatisticsusingANOVA

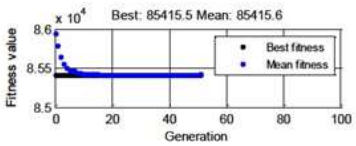
ANOVA						
	df	SS	MS		F	SignificanceF
Regression	1	3198110075	3198110075		14.78798	0.003236
Residual	10	2162641479	216264147.9			
Total	11	5360751554				
	Coeflcients	StandardError	tStat	P-value	Lower 95.0%	Upper95.0%
Intercept	29300.6	37352.97934	0.784425135	0.450973	112528	53927.01
XVariable1	4319.441	1123.241284	3.845514379	0.003236	1816.703	6822.178

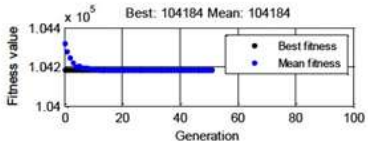
Figure3showstheSimulationanddatavalidationof ForecastedvaluewithGeneticAlgorithm. Itisfound that theForecastedresultasshown intheTable1isunder the Normalcy. Similar tothe ACOutput Forecast, statistical analysisofTemperatureisshowninthe 5.

Table5and 6shows the StatisticalanalysisofTem- peratureHistogramover18yearsandRegressionanalysis using ANOVAforTemperaturerespectively.Theone-wayanalysisofvariance(ANOVA)isusedtodeterminewhether there areanystatisticallysignificant differences between themeansoftwoormoreindependentgroups.Heredfrep- resentsthedegreeoffreedomwhichis1forRegressionand16forResidual inthispresentstudy. Significance Frepre- sents theratioofMeanSquareErrortoSumSquareError, which isunity inthepresentcase.Thissignifiesthat the forecastedresultforsolarPVisthebestaccurateonewith respect totemperature.TheF-testisused forcomparing thefactors ofthetotal deviation.Inthepresentanalysis ofANOVAF isfoundtobe22.1812whichisinsidethepre- scribedlimitofF.

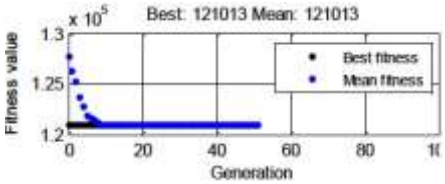
Table4: ProbabilityOutputVs.PredictedOutput

Obse	RESIDUALOUTPUT	PROBABILITYOUTPUT

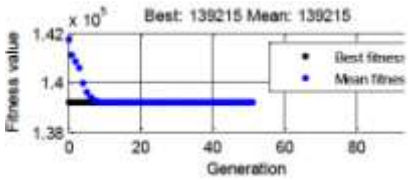




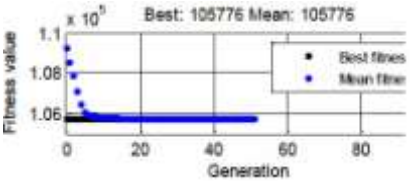
(a) BestFitnessValueorForecastedSolarPV SystemfortheMonthofJanuarry
(b) BestFitnessValueorForecastedSolarPV SystemfortheMonthofFebruary



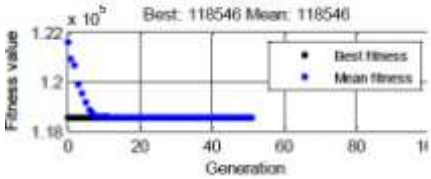
(c) BestFitnessValueorForecastedSolarPV SystemfortheMonthofMarch



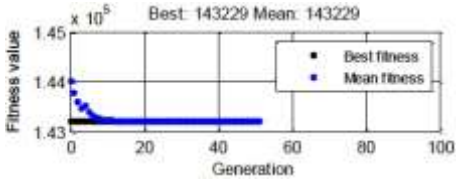
(e) BestFitnessValueorForecastedSolar PVSystemfortheMonthofMay



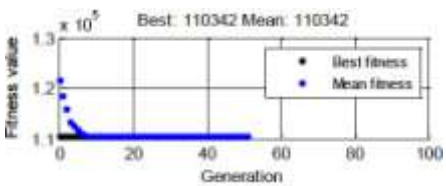
(g) BestFitnessValueorForecastedSolarPV SystemfortheMonthofJuly



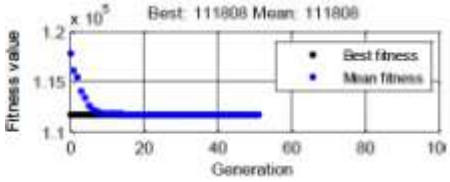
(i) BestFitnessValueorForecastedSolarPV SystemfortheMonthofSeptember



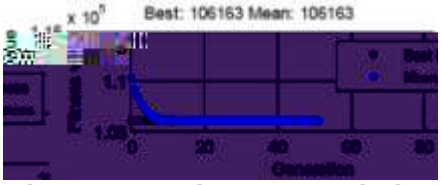
(d) BestFitnessValueorForecastedSolarPV SystemfortheMonthofApril



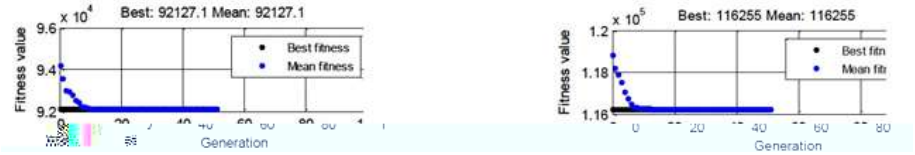
(f) BestFitnessValueorForecastedSolarPV SystemfortheMonthofJune



(h) BestFitnessValueorForecastedSolarPV SystemfortheMonthofAugust



(l)BestFitnessValueorForecastedSolar PVSystemfortheMonthofDecember



(j) BestFitnessValueorForecastedSolarPVSystemfortheMonthofOctober
(k) BestFitnessValueorForecastedSolarPV SystemfortheMonthofNovember
Figure3: ShowstheBestFitnessValueorForecastedSolarPVSystemfortheeverymonthofYear

Conclusion

The level ofsolar Power that can begeneratedbyaso- larphotovoltaicsystemd epend supontheenvironmentinwhichitisoperatedandtwootherimportant factor liketheamountofsolarinsolationand temperature. Application of GAto Forecasting of theSolarACoutput systemisdis- cussed inthispaper. Itisfoundthatthe forecastingusing GA ismuchmo reconvenient and accurateascomparedto statisticalmethod of analysis. Inthenextpaperof thisse- riesOptimisation of SolarPV Output withrespect totwo variable such asTemperatureaswellas Solar Radiation will be presented.GridconnectedsolarPhotovoltaicissues based ontheForecastedresult and their mitigationtech- niques willbediscussedinfuturework.

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