National College of Ireland

Transiting Planet Search in the Kepler Pipeline Using Automated Machine Learning

MSc Research Project
Data Analytics

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Project Submission Sheet
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Student Name:	Martin Mohan
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Programme:	Data Analytics
Year:	2020
Module:	MSc Research Project
Supervisor:	Catherine Mulwa
Submission Due Date:	19/08/2020
Project Title:	Transiting Planet Search in the Kepler Pipeline Using Automated Machine Learning
Word Count:	13625
Page Count:	69

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Transiting Planet Search in the Kepler Pipeline Using Automated Machine Learning

Martin Mohan
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1 Introduction

This document (Configuration Manual) accompanies the Technical Report of the same title "Transiting Planet Search in the Kepler Pipeline Using Automated Machine Learning". It explains the technical details required to reproduce the hardware/software.
Initially the hardware setup is described 2.1. This is followed by a description of the software environment 2 and the software used 3.
An overview of the software pipeline is reproduced in section 4 and the components of the pipeline then discussed individually. The pipeline follows the **SEMMA** approach and this configuration manual is also constructed in this manner. The chapter **S**ample 5 describes how data was obtained. This is then followed by **E**xplore 6, **M**odify 7, **M**odel 8 and **A**ssess 9.
The pipeline combined **T**ransit **C**rossing **E**vents (**TCE**) and **K**epler **O**bjects of **I**nterest (**KOI**) to find **P**lanetary **C**andidates (**PC**s) using machine learning.

2 Environment Setup

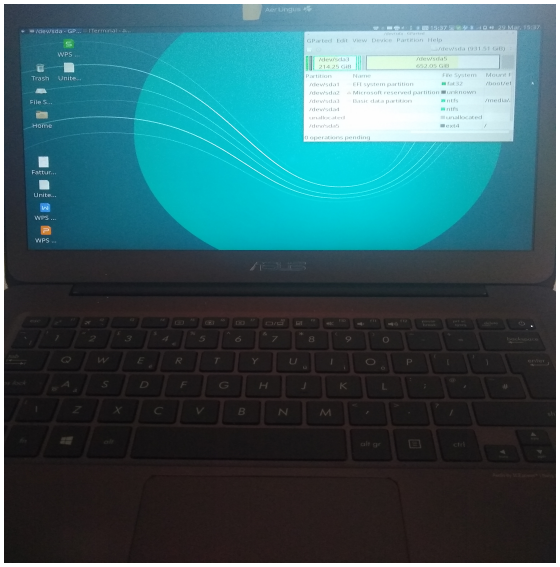
2.1 Computer Hardware

A desktop and laptop running on linux were used for development see Figure 1. The laptop contained 100GB ssd memory and the desktop contained a mixture of ssd and rotating disks.

2.2 Operating System Environment

Both computers in Figure 1 came with Windows 10.0 pre-installed and in both cases the file systems were modified to be dual boot with ubuntu 18.04 and 19.10. Development was performed on the ubuntu environment illustrated in Figure 2 in order to take advantage of the linux command line and shell scripts.

(a) HP - OMEN 875-0051 Gaming PC
2 TB HDD / 256 GB SSD disk
Intel® CoreTM i7, RTX 2060



(b) Asus Zenbook UX30FA laptop
1TB SSD disk
Intel® 5Y10 CPU @ 0.80GHz

Figure 1: Hardware used

3 Software Development Environment

3.1 Package Management with Anaconda

Ubuntu comes with a package manager pre-installed called aptitude but Anaconda [1] was preferred over aptitude because ...

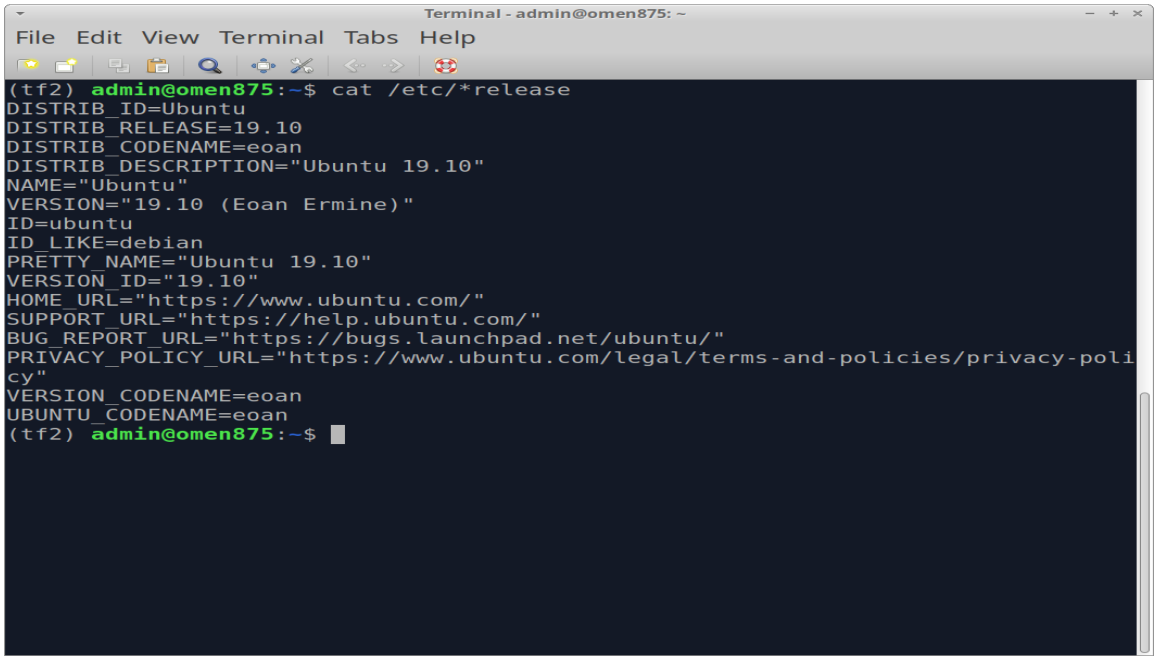
- Virtual environments can be created with Anaconda
- Anaconda packages provide a larger selection and more recent packages.
- Root access is not necessary to install packages

All software packages mentioned were installed using anaconda e.g. To add the caret library to r type.
conda install r-caret - see Figure 3

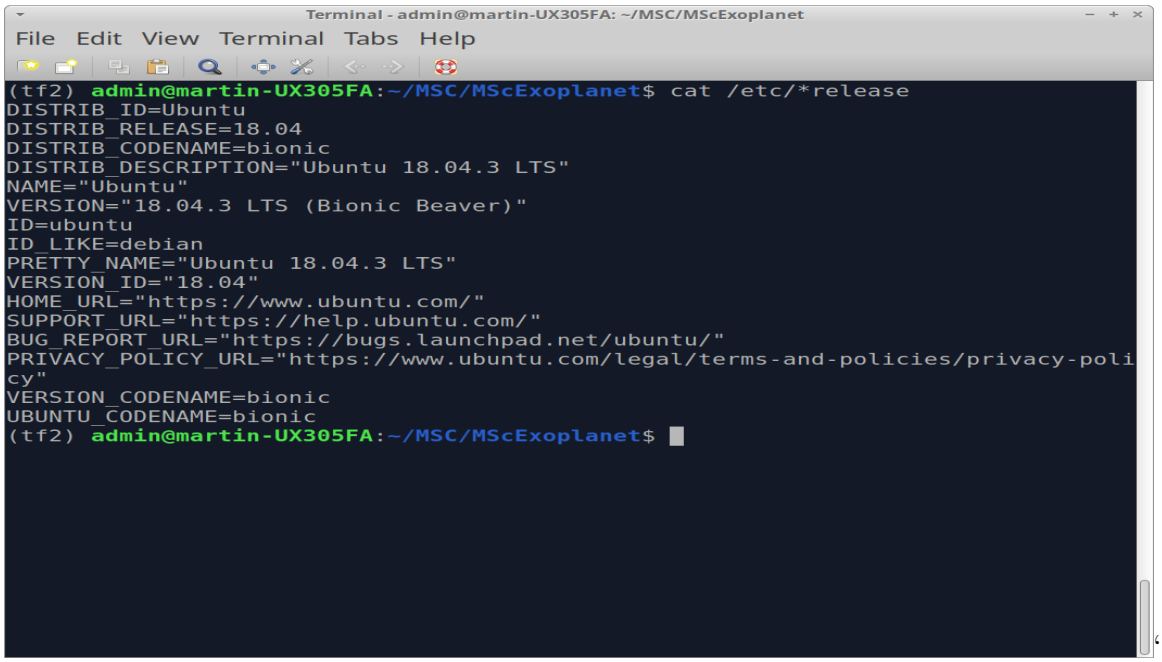
3.2 Packages Installed with Anaconda

Multiple software was installed on top of the conda environment Figure 3. The list of important software installed for this experiment is shown in Table 1.
The software installed was used for Treatment [a] options described in the pipeline shown in Figure 6. At each stage of the pipeline csv files were used to store the input and output were possible.

[1] `https://phoenixnap.com/kb/how-to-install-anaconda-ubuntu-18-04-or-20-04`



(a) Omen desktop ubuntu config



(b) Asus ubuntu config

Figure 2: Ubuntu linux environment on Omen Deskop and Asus laptop

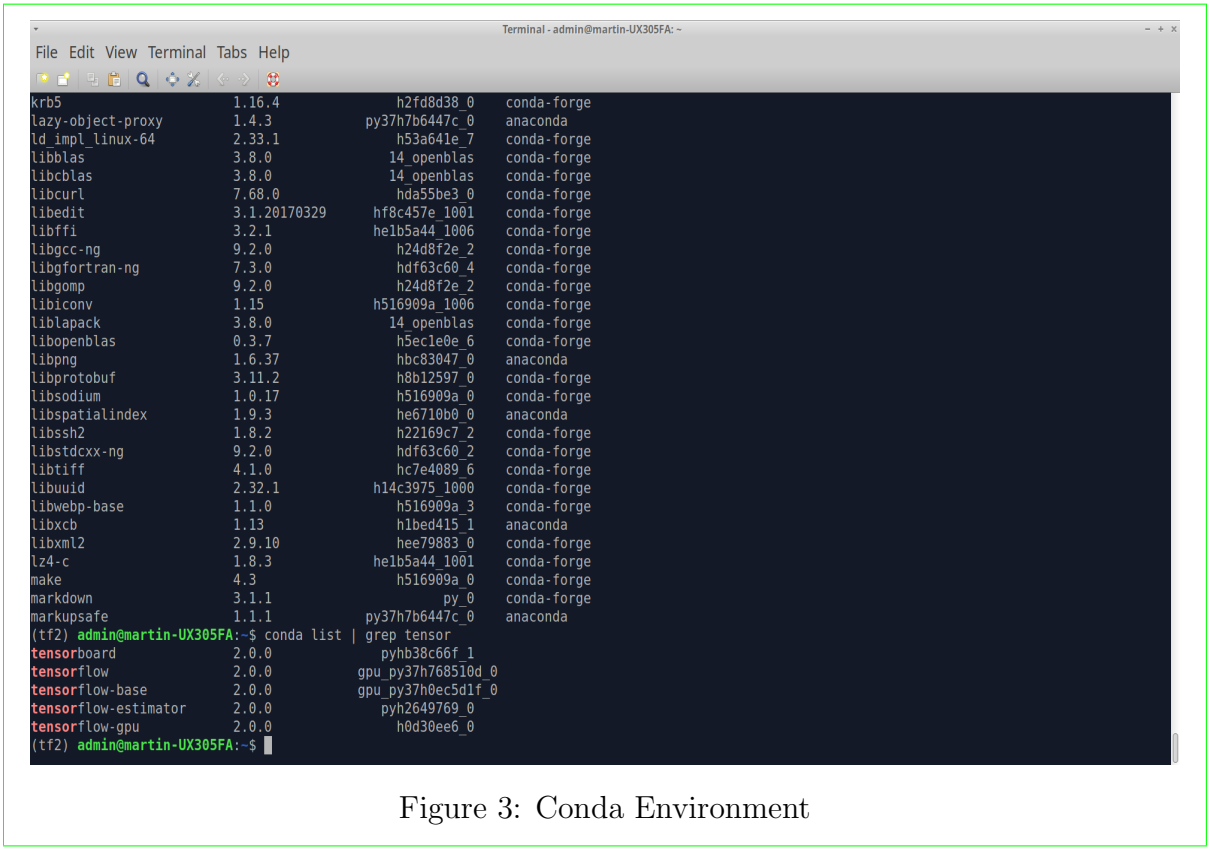


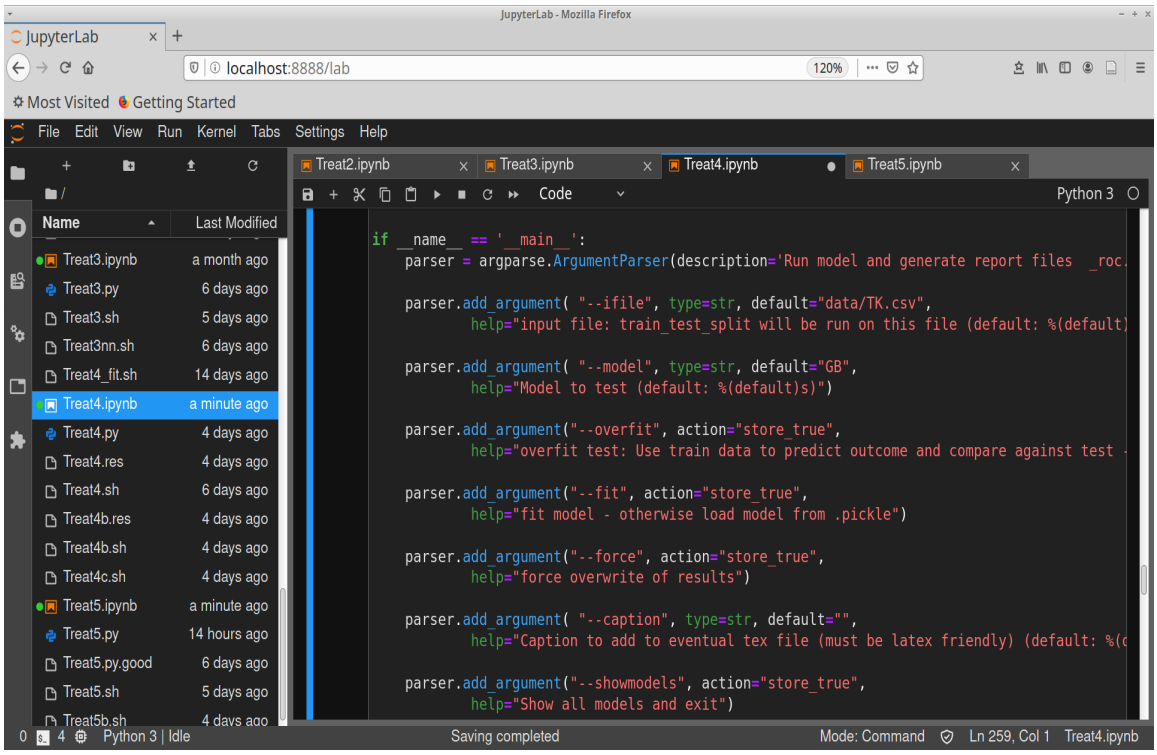
Figure 3: Conda Environment

Table 1: Important SW Packages installed

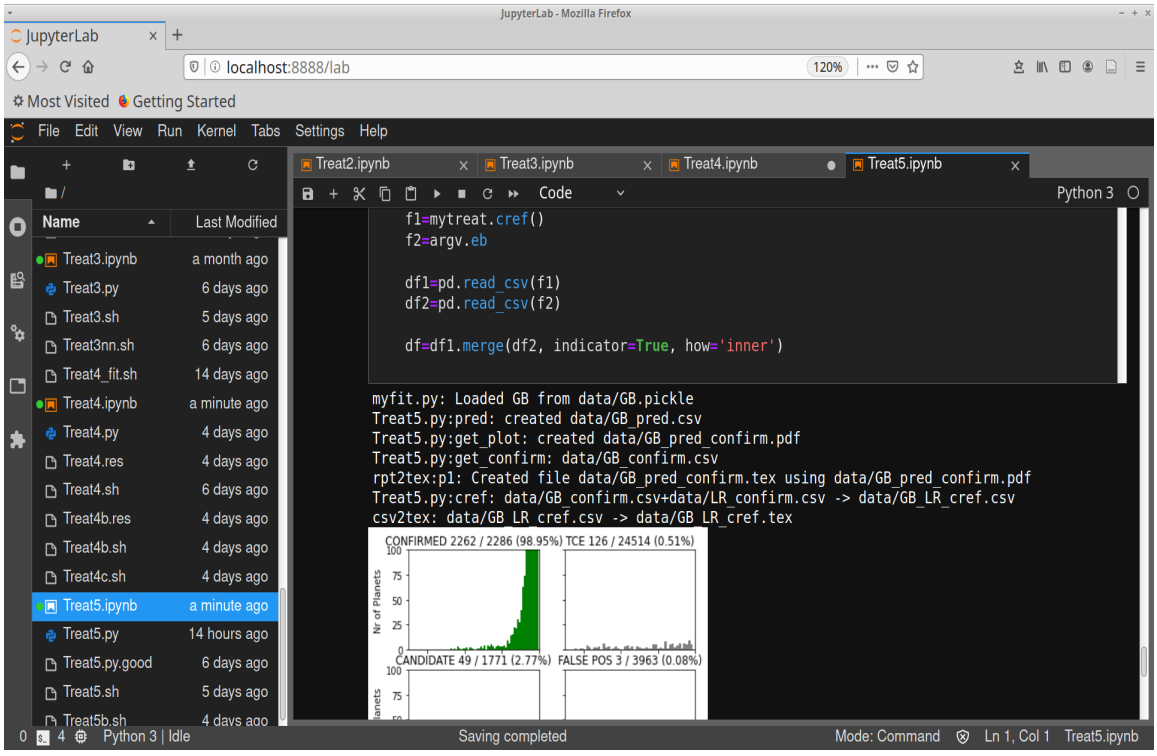
Package	**Uses**
Rstudio 11	**R** Interactive statistical analysis and data processing 10
Jupyter Lab	**Python3** interactive development and app development.
Argparser lib Python and R	A command line interface to Python and R. Initial development was done in jupyter lab and rstudio but this was then modified to be a command line interface for the pipeline.
IBM SPSS	Used for general statistical analysis.
Linux tools	Shell scripts, Text editing(vim),remote tools rsync, screen, ssh etc ...
texstudio	Texstudio was used for latex documentation and diagrams were designed using the Tikz package.
tpot	Automated software machine learning package Olson and Moore (2019).

3.3 Development Environment

Jupyter lab was used for initial python development see Figure 4 and rstudio was used for initial R development see Figure 5. Once developed the software was put into a command line the see section 4. All other development was performed using the vim text editor see Figure 8 (a).



(a) jupyter lab: The argparser package was used to create a command line interface



(b) jupyter lab: matplot was used to generate graphics

Figure 4: jupyter lab used for python development

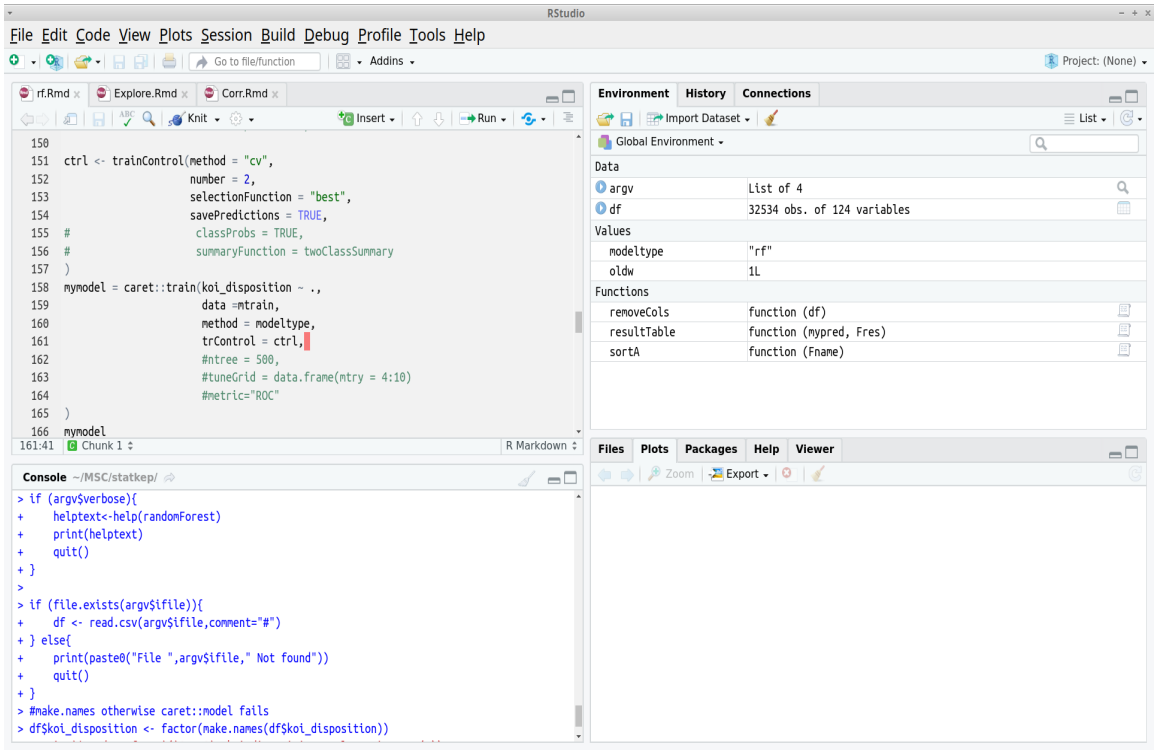
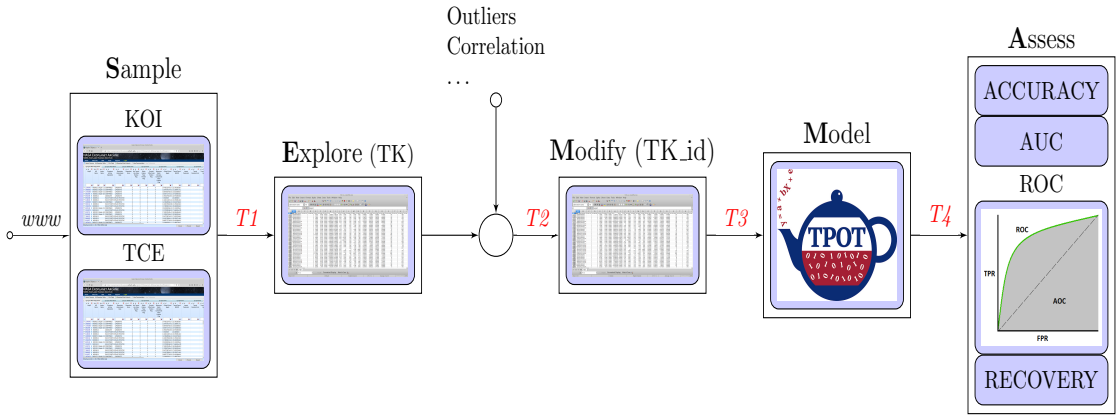


Figure 5: Rstudio used initially for development and then for data Exploration.

4 Pipeline Overview

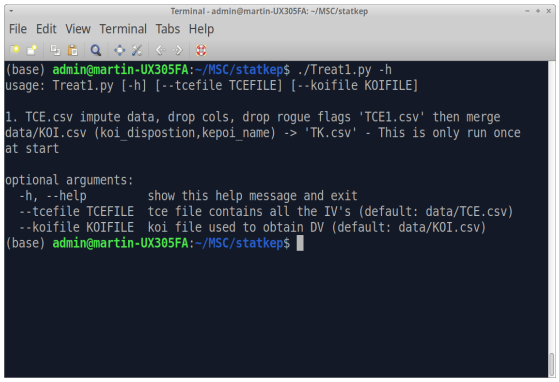
An overview of the python software pipeline is reproduced in Figure 6 and an overview of the command line are shown in Figure 7.
The programs generated multiple file names. Unit tests were used to test these programs by deleting these files and then checking they are re-created correctly by the programs see Figure 8.



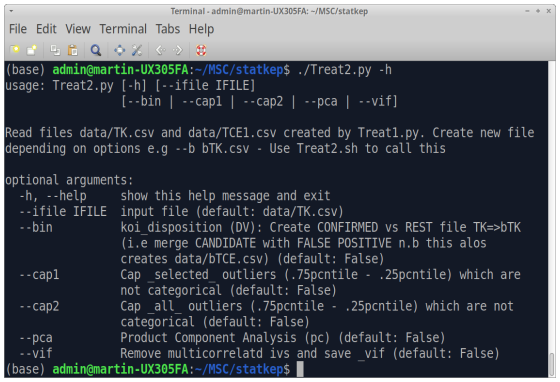
Input	Output	Treat [a]
TCE.csv[2] KOI.csv[4]	TK.csv	*T1*: TK.csv was a file which was the result of downloading two tables, which were merged and pre-processed to create a single table TK.csv containing multiple IV's and one DV.
TK.csv	TK_**id**.csv	*T2*: After exploration TK.csv was modified creating several modifications based on removing correlation or outliers. These modifications were identified using a unique **id**.
TK_id**.csv**	TK_id**.py**	*T3*: The file TK_id was input to the TPOT software Randal S. Olson and Jason H. Moore (2018) which performs feature selection and tuning in order to provide a python program with the best prediction model.
TK_id.py	Performance results	*T4*: The models created by TPOT were evaluated against holdout data for Precision, Accuracy and AUC. They were also tested for overfitting.
TK_id.py	Recovery results	*T5*: The best models were run against the original **TCE** file to check if any new exoplanets could be found

[a] *Treatment* refers to programs which modify or evaluate the data. *T1*, *T2*, *T3*, *T4*, *T5*

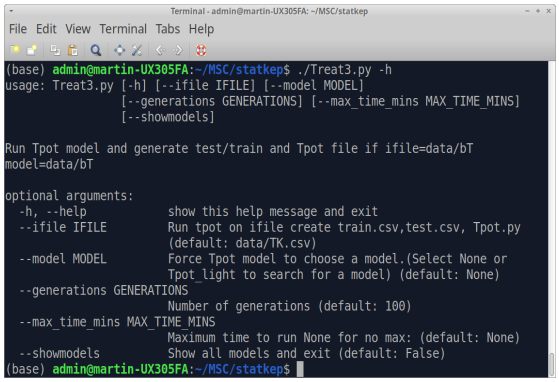
Figure 6: SEMMA pipeline Overview: Each *T*reatment has a defined input and output which is usually a csv file



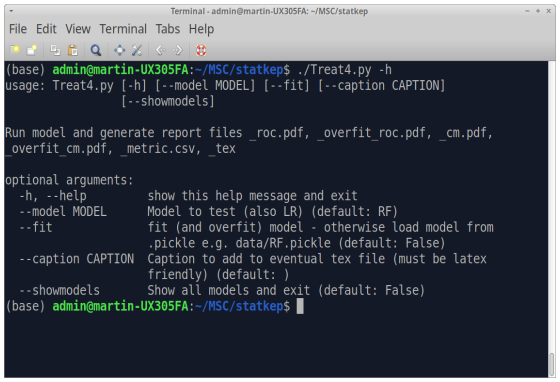
(a) Treat1.py



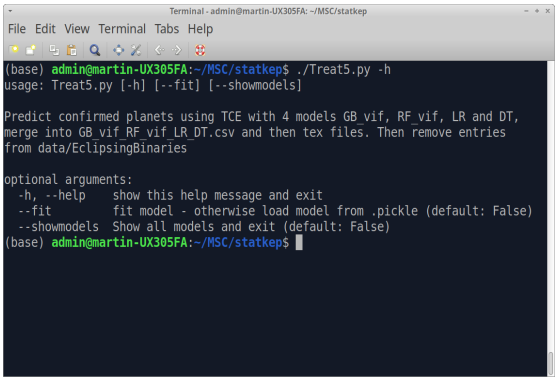
(b) Treat2.py



(c) Treat3.py

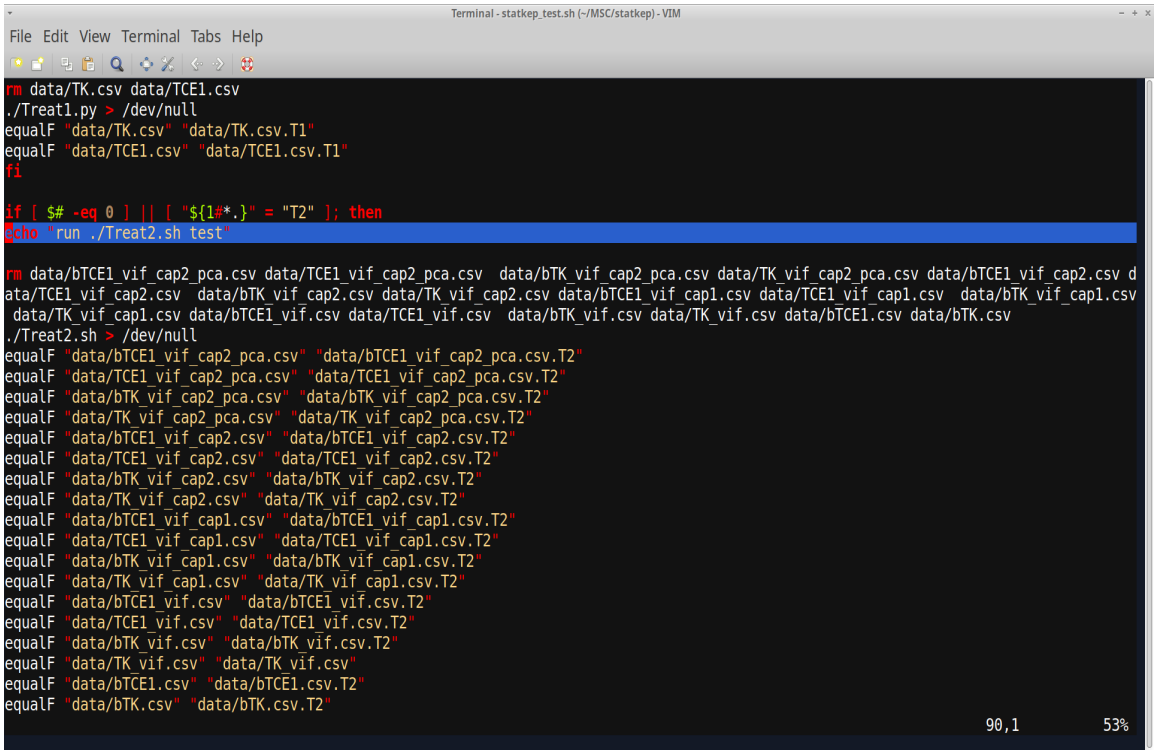


(d) Treat4.py

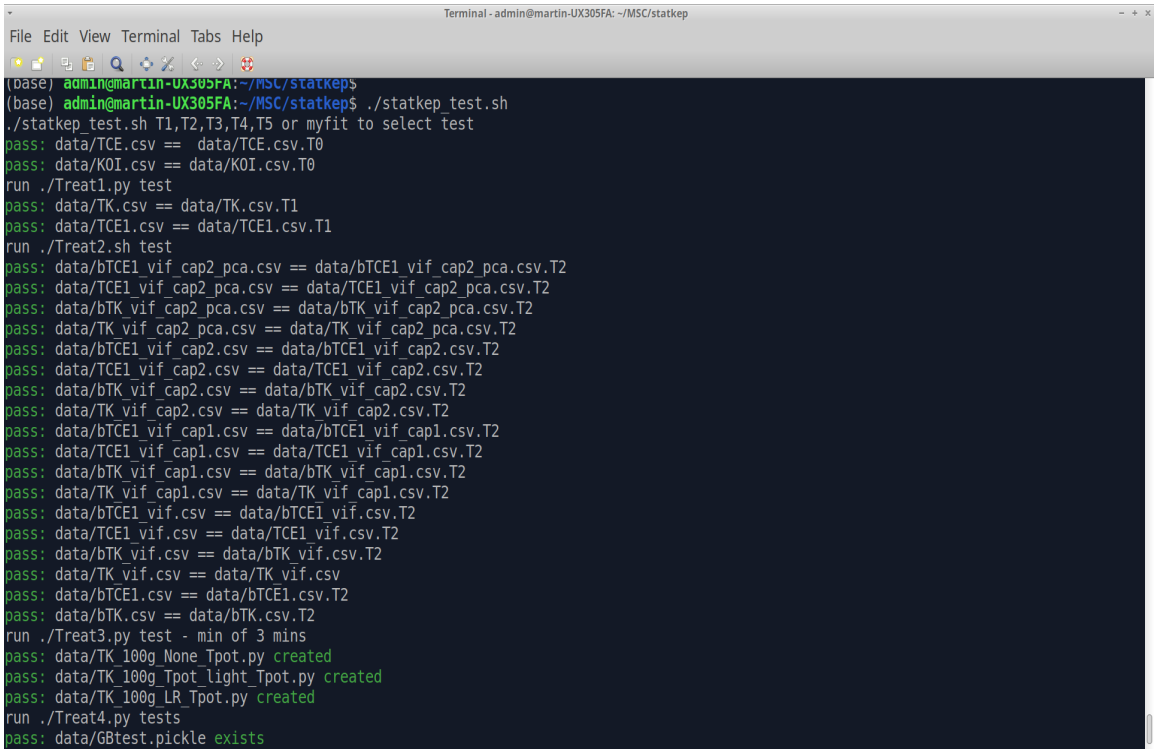


(e) Treat5.py

Figure 7: Overview of help files for applications Treat1,2,3,4,5



(a) Test script bash source code



(b) Test script - output

Figure 8: statkep_test.sh: Unit tests for Treat1,2,3,4 and 5. Files removed and unit tests run to see if they are re-created correctly

5 Sample.py Treat1.py

Two files were downloaded and merged from NASA's exoplanet archive, Threshold crossing event (TCE) [2] [3] and KOI.csv [4] [5]. The two files were merged to produce a single csv file called TK.csv with 8020 rows and 126 columns.
The help options of the program used to merge the program are shown in Figure 9 and the treatment involved is summarized in Table 2. Table 3 shows how the tables are merged. Regression tests described in the previous sections were applied to Treat1.py see Figure 8

[2] table: `https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TblView/nph-tblView?app=ExoTbls&config=tce` last accessed 09/05/2020

[3] Description of TCE Data: `https://exoplanetarchive.ipac.caltech.edu/docs/API_tce_columns.html` last accessed 09/05/2020

[4] Kepler Object of interest (KOI) Data: `https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TblView/nph-tblView?app=ExoTbls&config=koi` last accessed 09/05/2020

[5] Description of KOI Data: `https://exoplanetarchive.ipac.caltech.edu/docs/API_kepcandidate_columns.html` last accessed 09/05/2020

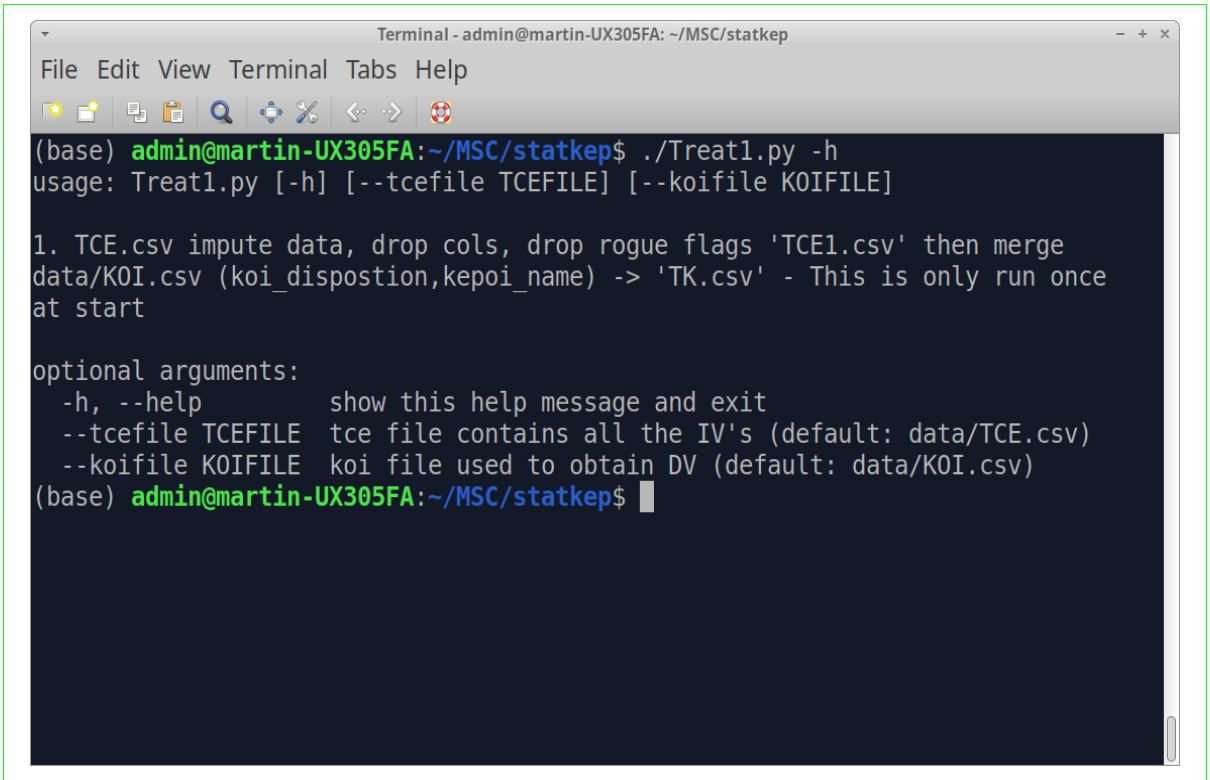


Figure 9: Treat1.py help screen

Table 2: Summary of program Treat1.py

Modification	**Reason**
Merge TCE.csv and KOI.csv	**KOI.csv** was merged with **TCE.csv** using the columns kepid, kepoi_name from TCE.csv and. kepid and kepoi_name from KOI.csv.**koi_disposition** is the dependent variable which was saved in 3 levels CANDIDATE, CONFIRMED or FALSE POSITIVE.
Drop	Several columns had the same value for every case. Other columns such as the Autovetter flags (start with av_) were empty and thus dropped
Factorize	Several values were factorised from strings to numbers
Imputation	Missing values were imputed using the 'most frequent' method
Convert signal and noist to _snr	Approximately thirty columns contained signals accompanied by thirty _err columns e.g. tce_period and tce_period_err. An error signal only makes sense unless it is associated with it's signal so these were merged to create a signal/noise ratio.

Table 3:
Merge TCE.csv and KOI.csv -> TK.csv
Calculate SNR: tce_period_sn=tce_period/tce_period_err

(a) TCE.csv (rows 34032,cols 156)

kepid	tce_plnt_num	tce_period	tce_period_err	etc...
11446443	1	2.47061	0.0000000205109	...
10666592	1	2.20473	0.0000000470213	...
3248033	1	1.33413	0.00000439602	...
7199397	1	105.88	0.000125931	...
10187017	6	22.41	0.000146598	...
...	...	...	...	...

(b) KOI.csv (rows 8054,cols 138) koi_disposition is the Dependent Variable

kepid	kepoi_name	koi_disposition	koi_period	etc...
11446443	K00001.01	CONFIRMED	2.470613377	...
10666592	K00002.01	CONFIRMED	2.204735417	...
3248033	K00006.01	FALSE POSITIVE	1.334101467	...
7199397	K00075.01	CANDIDATE	105.8817667	...
10187017	K00082.06	CANDIDATE	22.4098677	...
...	...	...	...	...

(c) TCE + KOI -> TK.csv

kepid	kepoi_name	koi_disposition	tce_period	tce_period_snr	etc...
11446443	K00001.01	CONFIRMED	2.47061	120453514.960	...
10666592	K00002.01	CONFIRMED	2.20473	46887899.739	...
3248033	K00006.01	FALSE POSITIVE	1.33413	303.49	...
7199397	K00075.01	CANDIDATE	105.88	840.14	...
10187017	K00082.06	CANDIDATE	22.41	152.86	...
...	...	...	...	...	...

6 Explore

The program Treat1.py created a single file TK.csv containing 124 IVs and 1 DV(koi_disposition). This was explored using various software like rstudio and spss. Results of the exploration are noted in the subsection below ...

6.1 Missing KOI's

An examination of the difference after merge revealed 25 KOI's were found with no equivalent TCE entry see Table 4

Table 4: Missing KOI's: KOI flags with no equivalent TCE entry

kepid	**kepoi_name**	**koi_disposition**	**tce_plnt_num**
12116489	K00547.03	CANDIDATE	3
10743597	K00989.02	FALSE POSITIVE	2
9411166	K01922.03	CONFIRMED	3
6041734	K02167.03	CONFIRMED	3
11030475	K02248.04	CANDIDATE	4
4247991	K02311.03	CONFIRMED	3
5602588	K02369.03	CANDIDATE	3
11968463	K02433.07	FALSE POSITIVE	7
8753896	K02473.03	CONFIRMED	3
12016267	K02590.02	CANDIDATE	2
9008737	K02768.03	CANDIDATE	3
10793172	K02871.04	CANDIDATE	4
9959492	K03051.02	FALSE POSITIVE	2
4735826	K03184.03	CANDIDATE	3
9008103	K03283.02	CANDIDATE	2
9230021	K03429.04	CANDIDATE	4
3937814	K04084.03	CANDIDATE	3
4548011	K04288.04	CANDIDATE	4
4953173	K04676.02	FALSE POSITIVE	2
8397947	K04772.03	FALSE POSITIVE	3
8973285	K04782.02	CANDIDATE	2
2861126	K04957.02	CANDIDATE	2
6363560	K05270.02	FALSE POSITIVE	2
7935997	K05447.02	CONFIRMED	2
10535708	K05801.02	FALSE POSITIVE	2

6.2 Near Zero Variance

The r-caret function [6] nearZeroVar exposed the tce_rogue_flag see Table 5 6.2.1. This flag was removed using Treat1.py but no other changes were made.

Table 5: Near Zero Variance Table: The tce_rogue_flag indicates a case with only 2 transits rather than 3 required for consistency so was removed

-	**freqRatio**	**percentUnique**	**zeroVar**	**nzv**
tce_rogue_flag	891.111	0.025	0	1
tce_full_conv	25.674	0.025	0	1
tce_sradius_prov	88.122	0.05	0	1
tce_rb_tcount2	19.637	0.71	0	1
tce_rb_tcount3	46.18	0.311	0	1
tce_rb_tcount4	41.129	0.262	0	1

6.2.1 tce_rogue_flag

tce_rogue_flag flags: rogue (or unintended) detections Coughlin et al. (2016) which should not be considered for inclusion in the DR25 KOI activity table [3] but nine cases were detected and removed.

Table 6: rogueFlags 9 rows: According to NASA these should not be in KOI table so they were removed

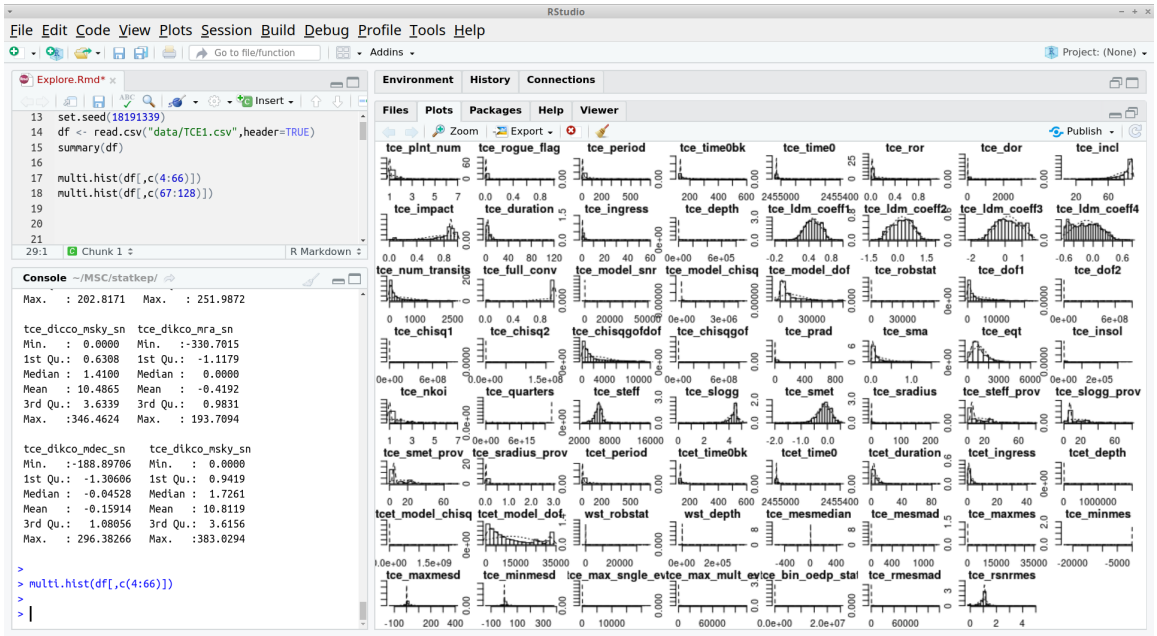
kepoi_name	**kepid**	**tce_plnt_num**	**tce_rogue_flag**
K04599.01	7335972	1	1
K06152.01	6967278	1	1
K07609.01	10267121	1	1
K07712.01	4996057	1	1
K07880.01	8308516	1	1
K08059.01	11612241	1	1
K08141.01	7686191	1	1
K08176.01	9084832	1	1
K08273.01	8108450	1	1

6.3 Outliers

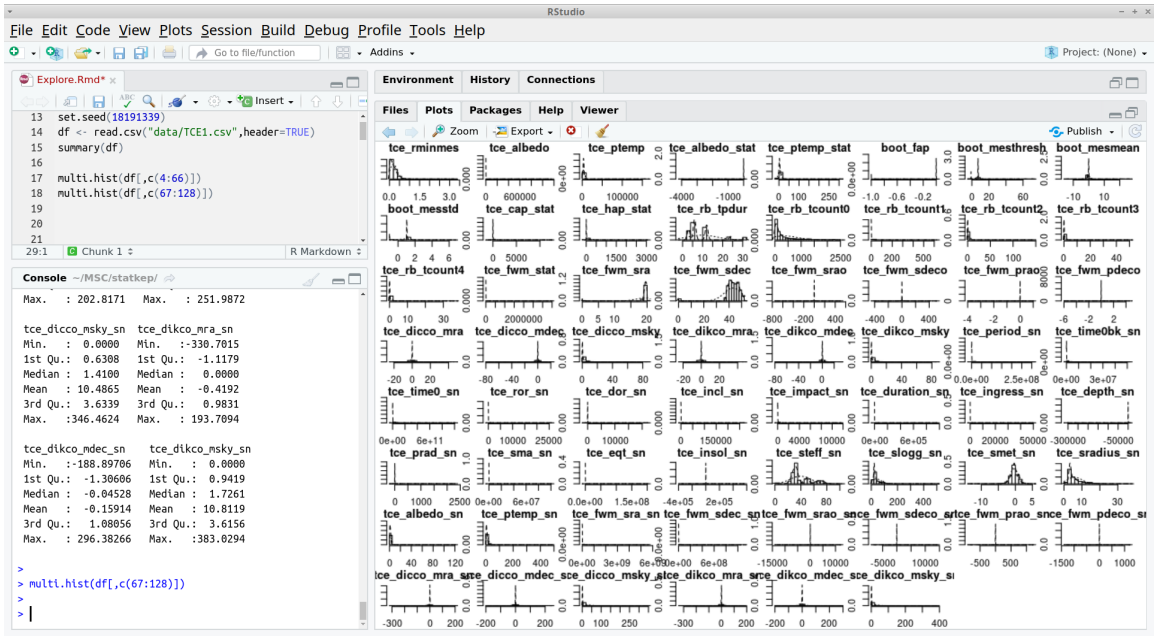
Rstudio and the function multi.hist from the package psych 10 were used to visualize the data. Box plots were viewed in Rstudio see Figure 11.
This lead to the removal of tce_quarters seemed to be a large outlier [7]. Removal of outliers sometimes improved the performance but the improvement was not considered significant for further investigation see the Technical Report.

[6] `https://topepo.github.io/caret/pre-processing.html#zero--and-near-zero-variance-predictors`

[7] The highest outlier tce_quarters actually turned out to be a 12 digit string used for identification rather than a measurement and was removed



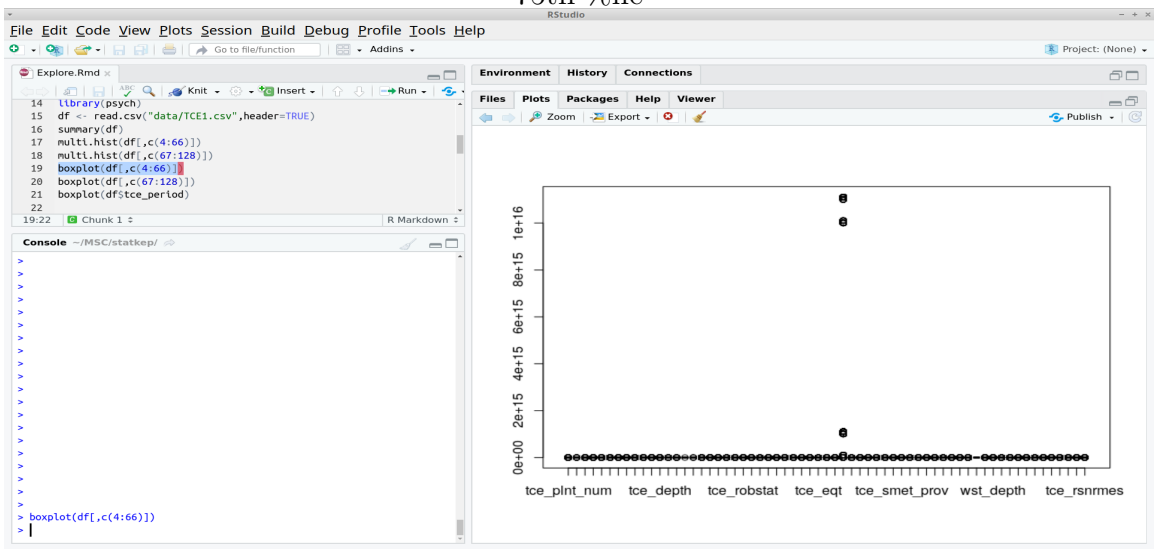
(a) Skew and Kurotosis for results IVs 4:66



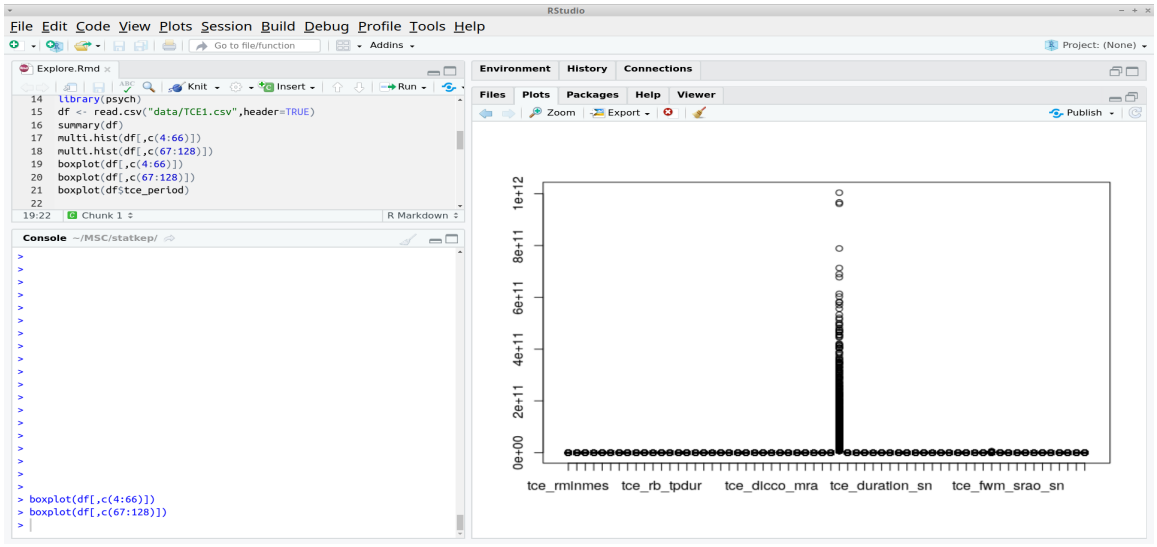
(b) Skew and Kurotosis for IVs 67:128

Figure 10: Graph showing histograms of Independent Variables

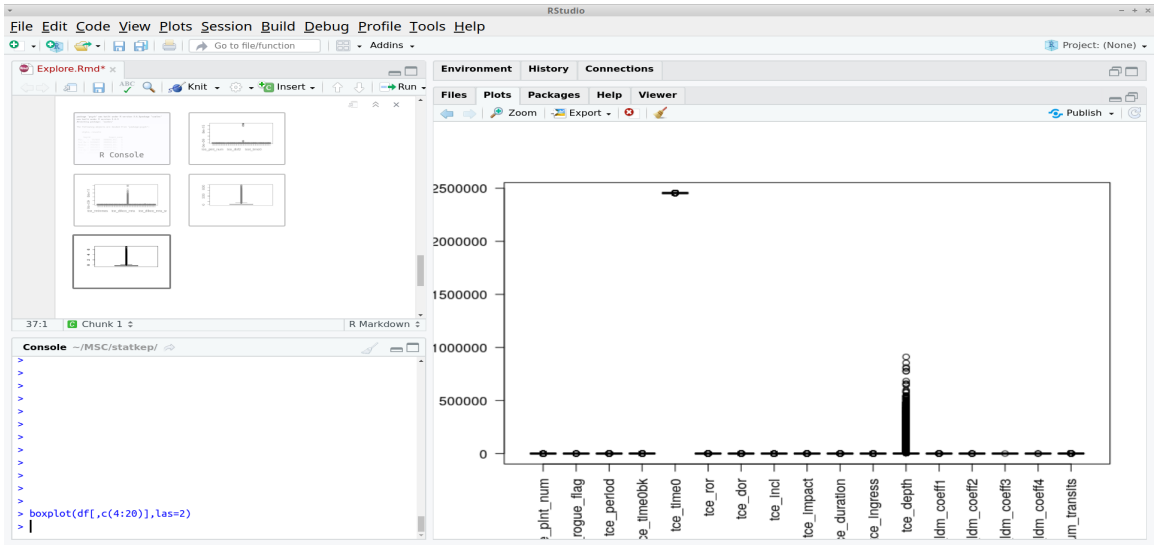
Cap:Interquartile range $3 * IQR$. Replace observations below 25th %ile and above 75th %ile



(a) Boxplots IVs 4:66



(b) Boxplots IVs 67:128

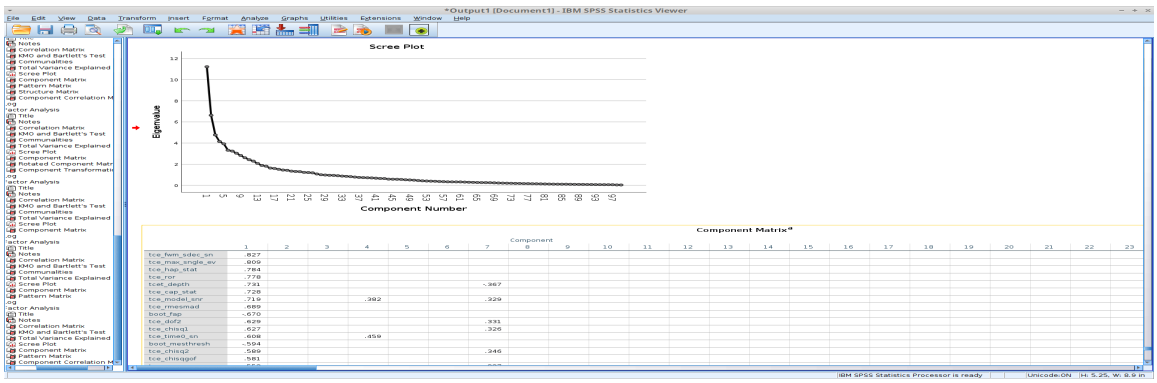


(c) Outliers can be identified by narrowing range

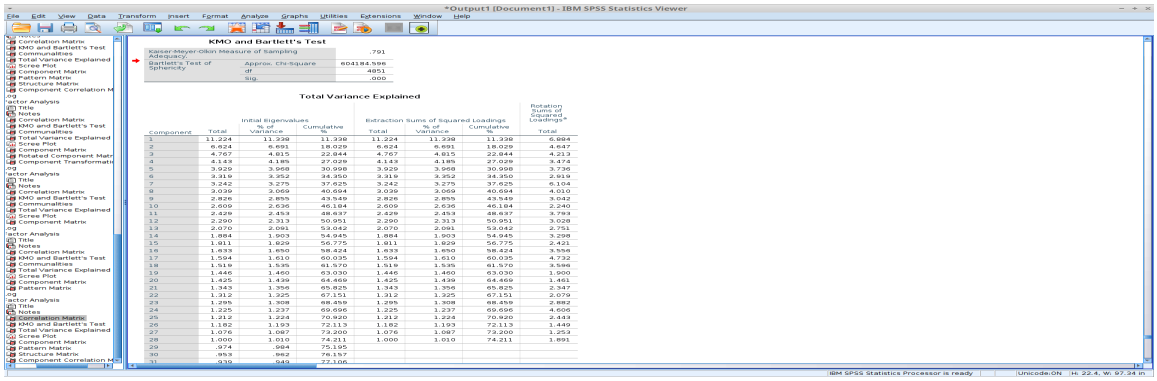
Figure 11: Boxplots of Independent Variables

6.4 Feature Selection

The suitability for factor analysis was assessed using SPSS version 26. Inspection of the correlation matrix revealed the presence of several values of .3 and above. The Kaiser-Meyer-Oilkin value was 0.791, exceeding the recommended value of .6 Dziuban and Shirkey (1974) and Bartlett's Test of Sphericity reached statistical significance, supporting the factorability of the correlation matrix.
An inspection of the Total Variance Explained and the Scree plot 12 showed no clean break and 28 components were required to explain 74.2% of the accumulated variance. Reducing the dimensionality of the data set before training a model will usually speed up training, but it may not always lead to a better solution; it all depends on the dataset Géron (2017).In large data sets IVs with small r values may still contribute significantly to prediction results. It was decided not to use the factor analysis as the loss in variance would not justify any gain in speed and **TPOT performs automatic feature selection** during tuning.



(a) Scree Plot and partial component matrix



(b) KMO/Bartlett and Total Variance Explained

Figure 12: Principal Component Analysis with IBM SPSS

6.5 Correlation with Dependent Variable (koi_dispostion)

High correlation of the DV (koi_diposition) with IV's is desirable so a table was created to explore IVs which contributed most to correlation see Table 7.

Table 7: koi_disposition vs highest correlated values

Nr	Name	R	Meaning
1	tce_nkoi	-0.3895	Number of Associated KOIs
2	tce_steff_sn	-0.3814	Stellar Effective Temperature [K]
3	tce_ror	0.3810	Planet-Star Radius Ratio
4	tce_dicco_msky	0.3579	PRF Δθ_{SQ}(OOT) [arcsec]
5	tce_dikco_msky	0.3556	PRF Δθ_{SQ}(KIC) [arcsec]
6	tce_chisqgofdof	0.3537	Chi-Square GOF DOF
7	tce_model_dof	0.3485	Degrees of Freedom
8	tcet_model_dof	0.3335	Degrees of Freedom
9	tce_incl	-0.3236	Inclination [deg]
10	tce_hap_stat	0.3220	Ghost Halo Aperture Statistic
11	tce_sradius_sn	-0.3184	Stellar Radius signal/noise ratio [Solar radii]
12	boot_fap	-0.3132	Bootstrap False Alarm Probability
13	tce_dikco_msky_sn	0.3117	PRF Δθ_{SQ}(KIC) sn ratio [arcsec]
14	tce_eqt	0.3104	Equilibrium Temperature [K]
15	tce_dicco_msky_sn	0.3080	PRF Δθ_{SQ}(OOT) sn[arcsec]
16	tce_smet_prov	-0.3070	Stellar Metallicity Provenance
17	tcet_ingress	0.3059	Ingress Duration [hrs]
18	tce_rb_tcount0	0.3036	Transit Counts 0
19	tce_steff_prov	-0.3015	Stellar Effective Temperature Provenance
20	tce_dof1	0.3005	Degrees of Freedom 1
21	tce_rsnrmes	-0.3000	Calculated Ratio SNR over MES
22	tce_depth	0.2941	Transit Depth [ppm]
23	tce_num_transits	0.2897	Number of Transits

7 Modify: Treat2.py

Highly correlated IVs are undesirable and were removed. The values to remove were determined by sorting IVs and removing those with the highest correlation iteratively. This was repeated until all those with a VIF > 10 were removed. The values with high VIF were noted and included in the program Treat2.py in order to remove these values automatically.
Treat2.py was used to clean the data. The structure of the program is shown in Figure 14. The help options of the program used to merge the program are shown in Figure 13 and the treatment involved is summarized in Table 8.

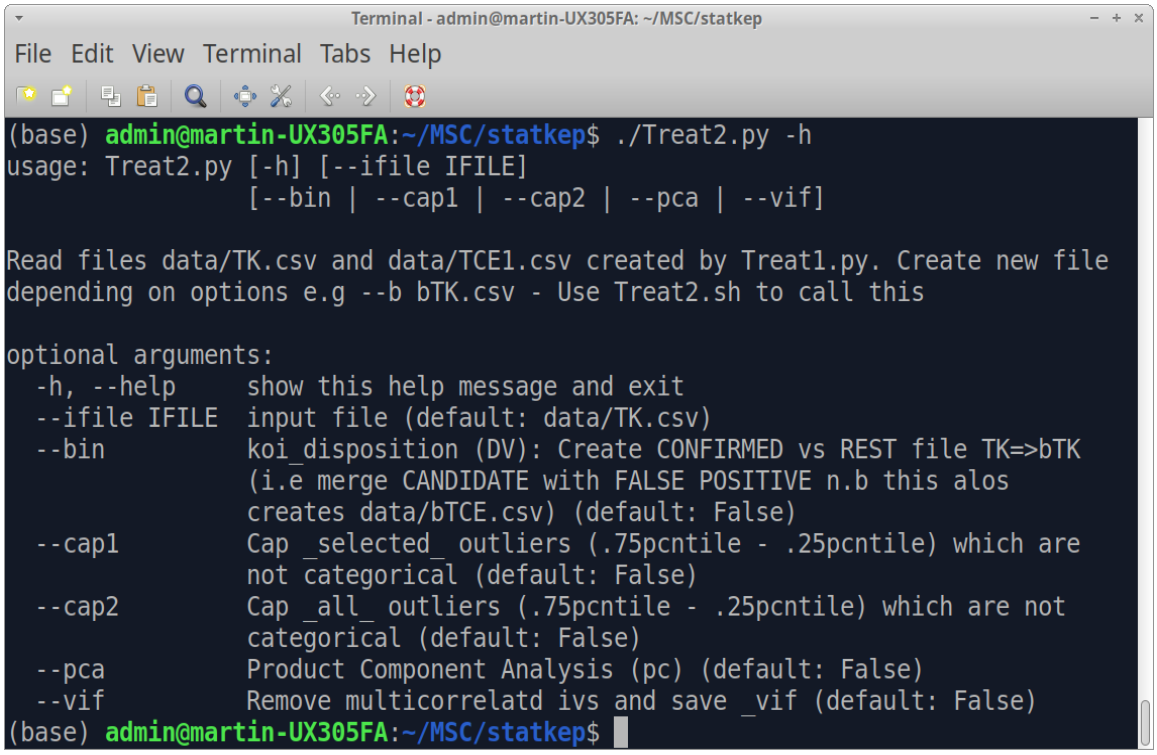


Figure 13: Treat2.py help screen

Table 8: Summary of program Treat2.py. Only highlighted options were used in the final report

Modification	**Reason**
bin	Investigations were carried out in changing from a multi-class system with 3 levels CANDIDATE, CONFIRMED or FALSE POSITIVE to a system with 2 levels CANDIDATE and FALSE POSITIVE. This was found to improve precision more but more programming is needed. The option is retained as it may be used in **future work**.
cap1	Capping was done by examining each curve individually and deciding on whether it should be capped but examining each IV individually proved too time consuming to be completed although the option is retained as it may be used in **future work**.
cap2	All values were capped at 3*(.25 %qtile to .75 %qtile). If this was applied to in input file the output file was automatically renamed with _cap2. 3*IQR was chosen after manual inspection of resulting output graphs using matplotlib. When this option is chosen a new filename with "_cap2" extension is created.
pca	PCA was attempted using python's pca software but inconclusive results were obtained so ibm-spss was used to investigate further. The option is retained as it may be useful for other projects in **future work**.
vif	Multicorrelated values were removed iteratively with the help of python program and jupyter labs. The Variant Inflation factor of each IV was calculated and sorted by size. The largest value was then removed and the process repeated until all values with VIF>10 had been removed. The final list of multicorrelated IVs was included in this program. This option will the IVs marked as having high vif from the data file and create a new filename with a "_vif" extension.

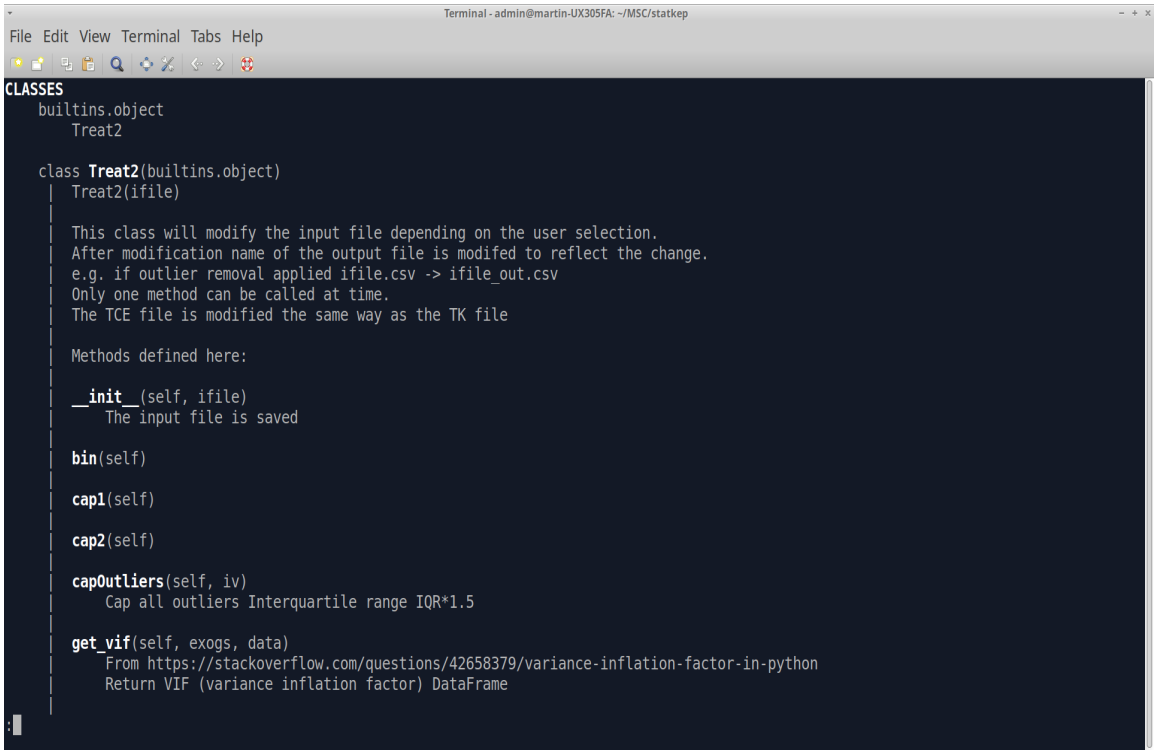


Figure 14: Treat2.py methods: To view: import Treat2;help(Treat2)

8 Model Creation using TPOT scripts: Treat3.py

Treat3.py was a wrapper used to create TPOT scripts.The help options of the program used to merge the program are shown in Figure 15 and the treatment involved is summarized in Table 9. After the model is configured it is run on the production desktop and generates a python script with optimized pipeline code see Figure 16. Each generated code is copied as a method to a python class mmodels.py see Figure 17 and this is used to assess the model by the programs Treat4.py and Treat5.py.

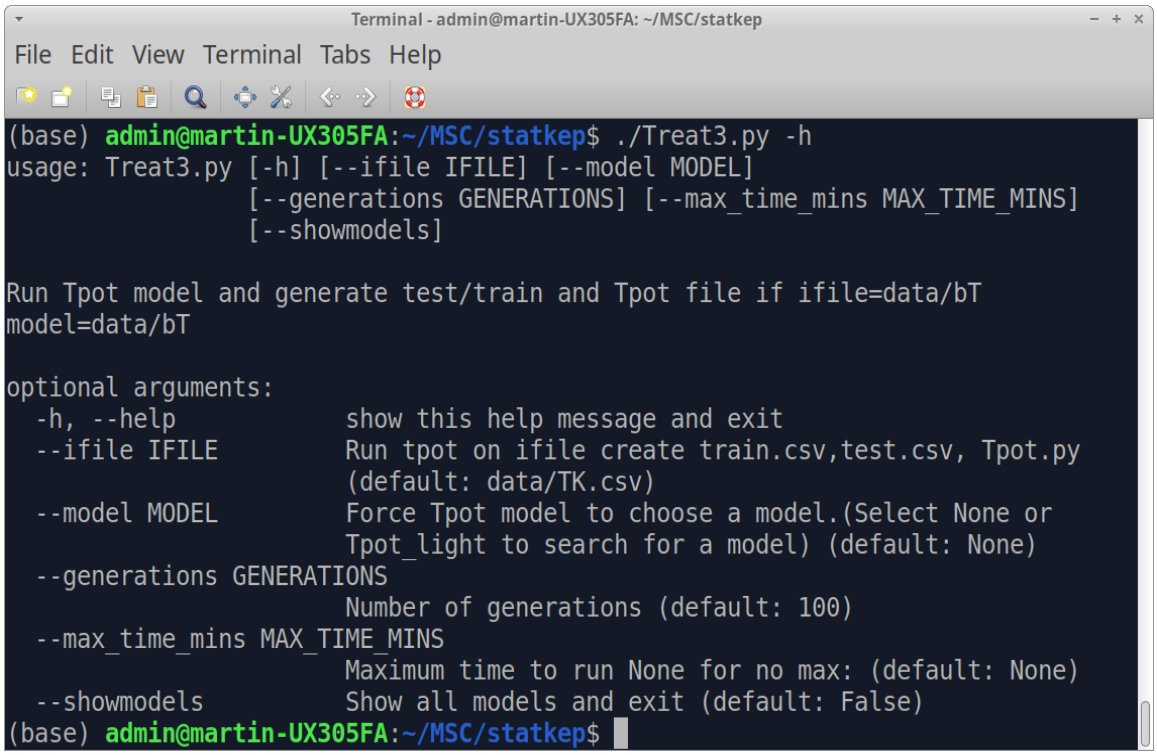
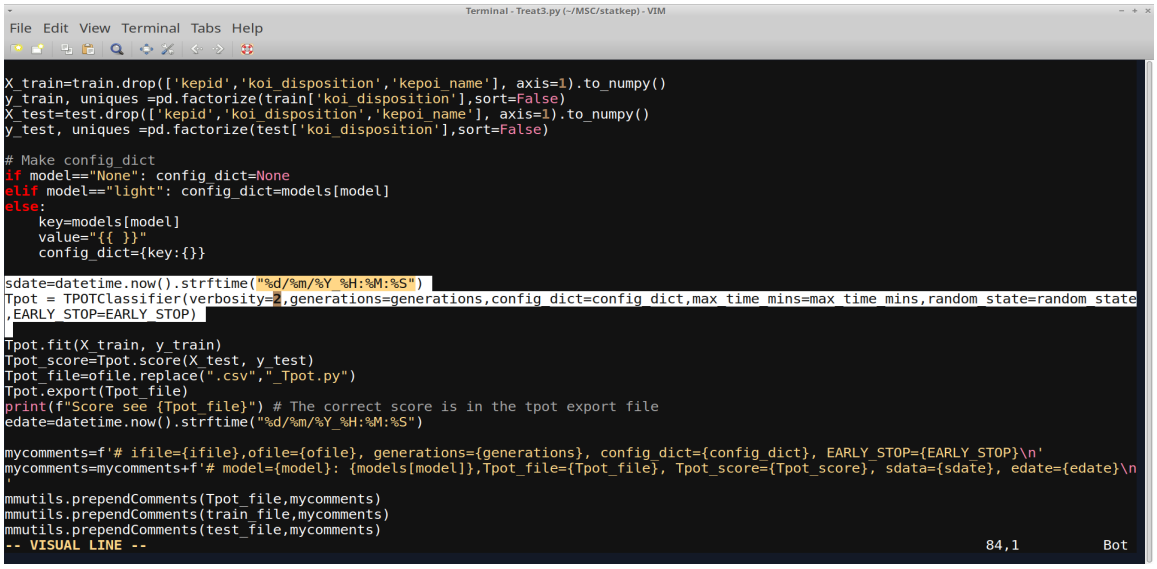


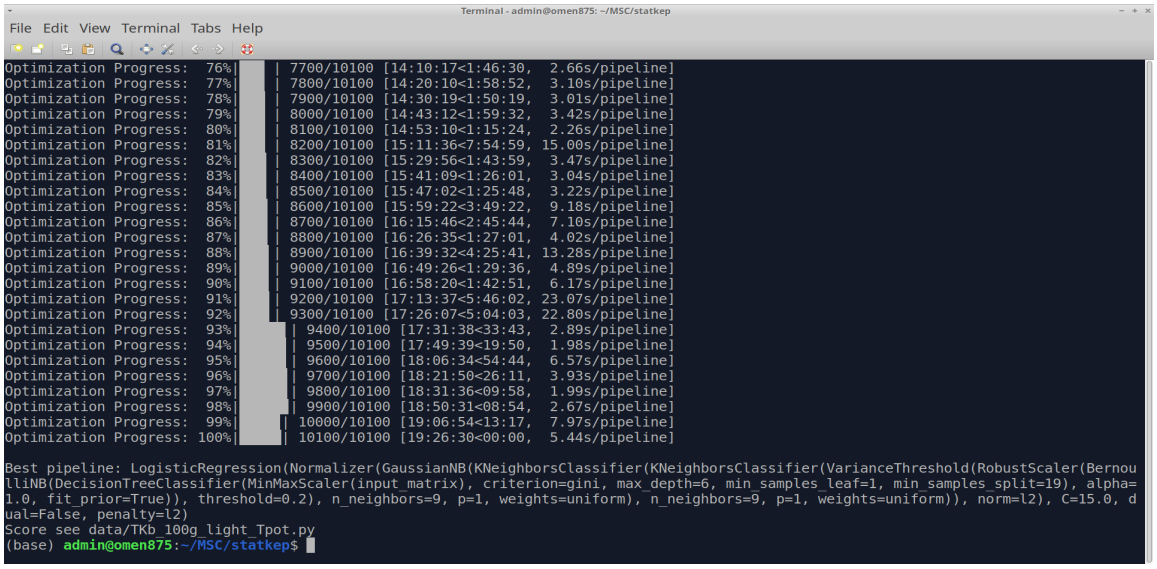
Figure 15: Treat3.py help screen

Table 9: Summary of program Treat3.py

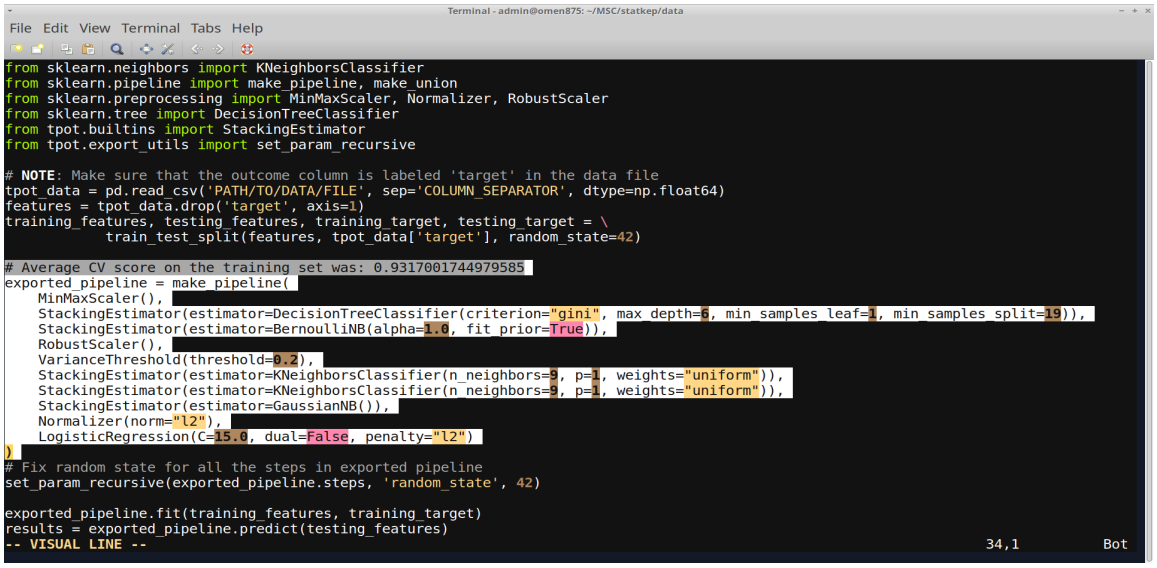
Modification	Reason
ifile	The file used by TPOT to generate automated machine learning code. The default is TK.csv but if data is modified e.g multicorrelation it is Tk_vif.csv
model	Restrict models tpots uses e.g.. 'TPOT light' uses lighter models. See –showmodels for models available. Only TPOT light and default TPOT produced significant results.
generations	Default is 100 but you can use less for faster models
showmodels	Show models available



(a) Tpot script on data to find optimal Configuration:100 generations used



(b) Optimization script duration 19 hours and 26 Minutes



(c) Optimal Model script automatically generated by tpot

Figure 16: TPOT generates the optimal script for modelling. In this case Logistic Regression see highlighted

9 Assess

Only LR and DT had results with high precision which were not overfitted by TPOT. Due to lack of space in the original report; additional results for performance are shown in section 9.1 and recovery in section 9.2.
Models generated by TPOT are shown in Figure 16 and described in the previous section. These scripts were copied into a class mmodels.py for use by the programs Treat4.py and Treat5.py see Figure 17. Performance results not included in the Technical Report are in sections 9.1.1, 9.1.2, 9.1.3 and 9.1.4.

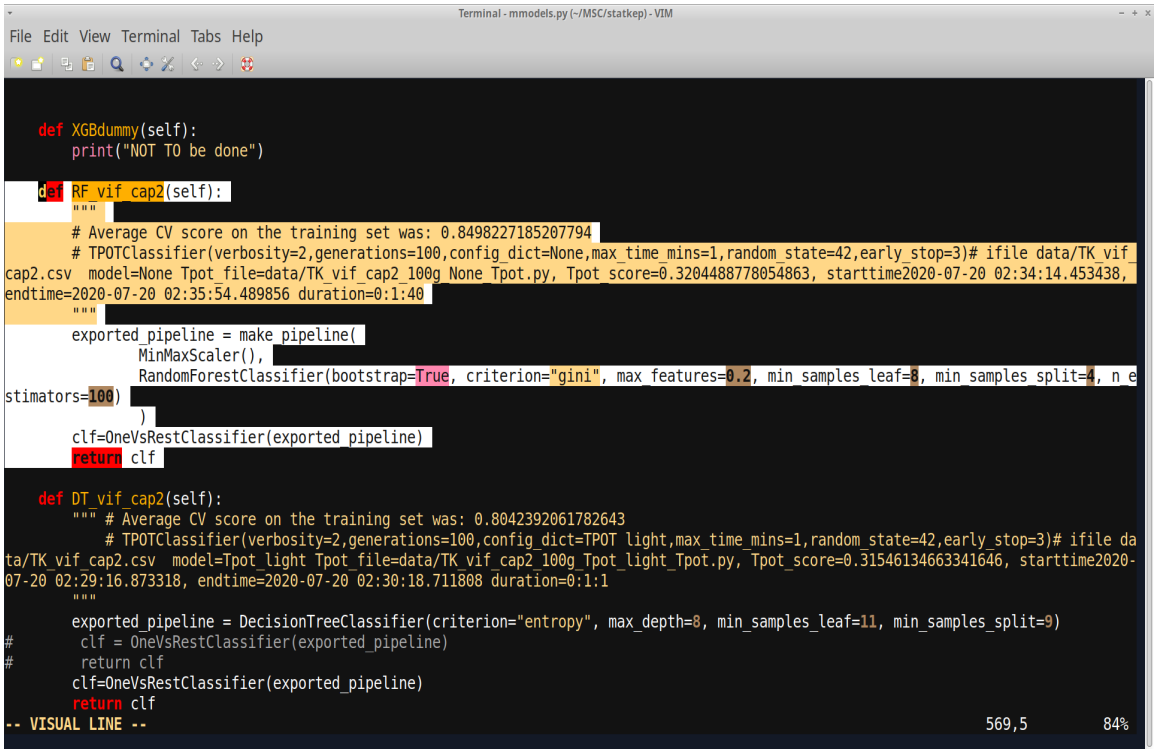


Figure 17: Each TPOT model copied from 16 , assigned unique name and saved as a method in the class mmodels.py

9.1 Performance Evaluation: Treat4.py

Performance evaluation was performed by the program Treat4.py. Help is shown in Figure 18 and the options described in Table 10. The program generated files containing graphs and metrics and a latex report see Figure 19.

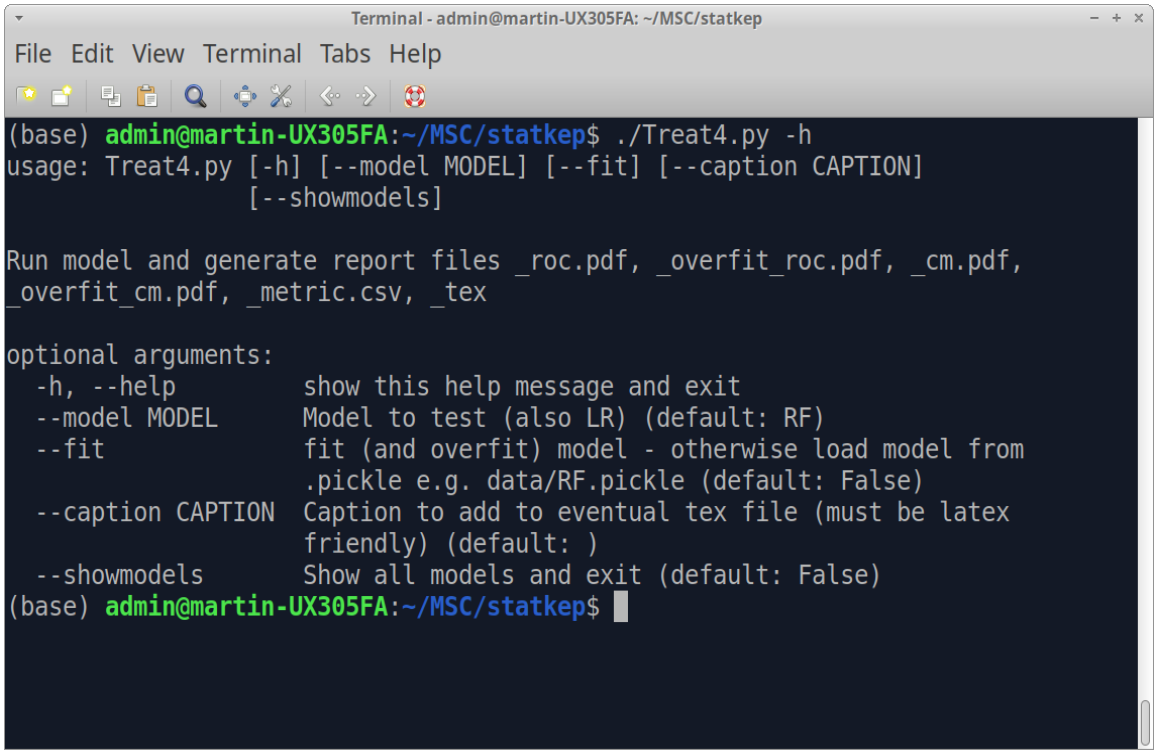


Figure 18: Treat4.py help screen

Table 10: Summary of program Treat4.py

Modification	Reason
model	The tpot model to be run
fit	By default the model will be loaded from a pickle file but if fit option is called the model will be called and create the pickle file.
caption	The model created will generate ROC curves and metrics. This option will add a caption
showmodels	Show models available

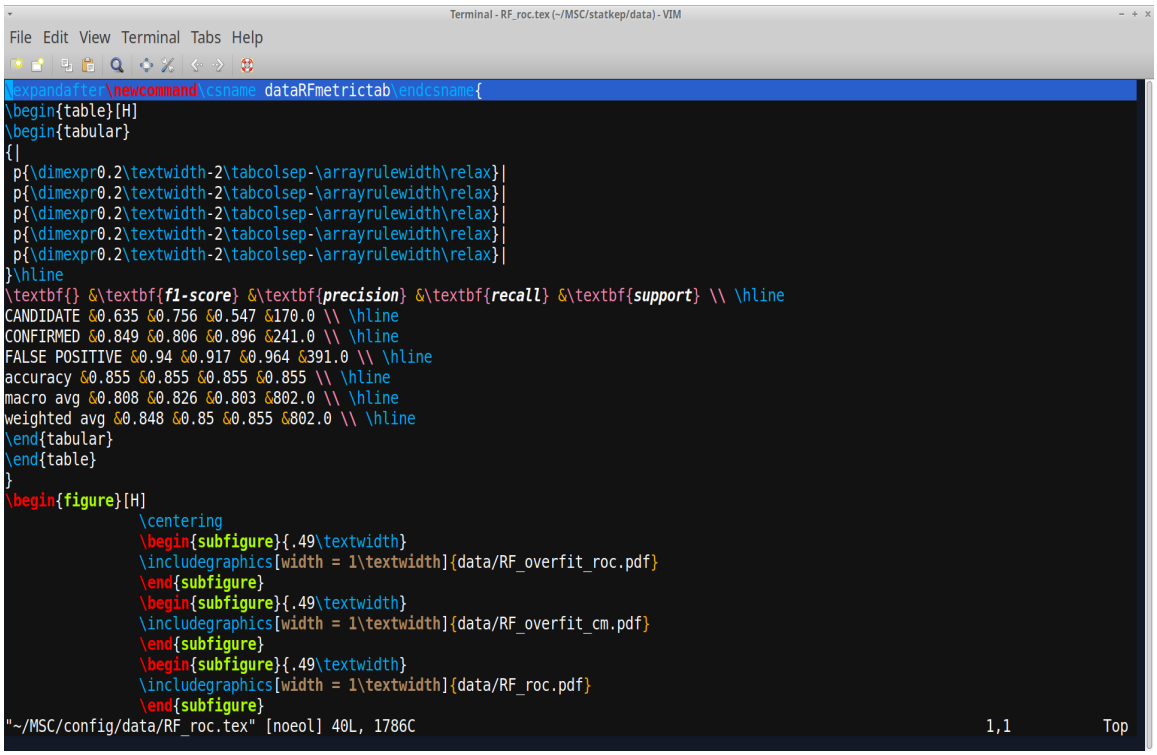
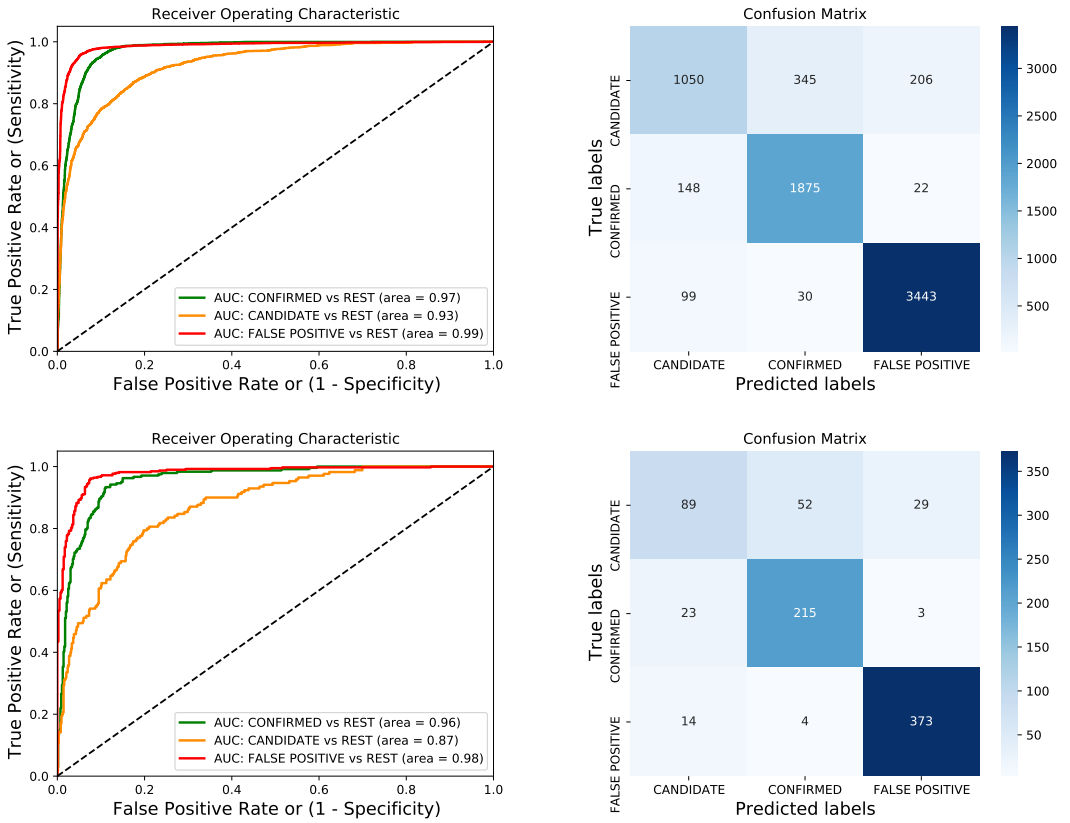


Figure 19: Treat4.py generates ROC pdf files using matplotlib and these are put into a file in latex format see Figure 30

9.1.1 Decision Tree

The Decision Tree performance is summarized in Figure 20.

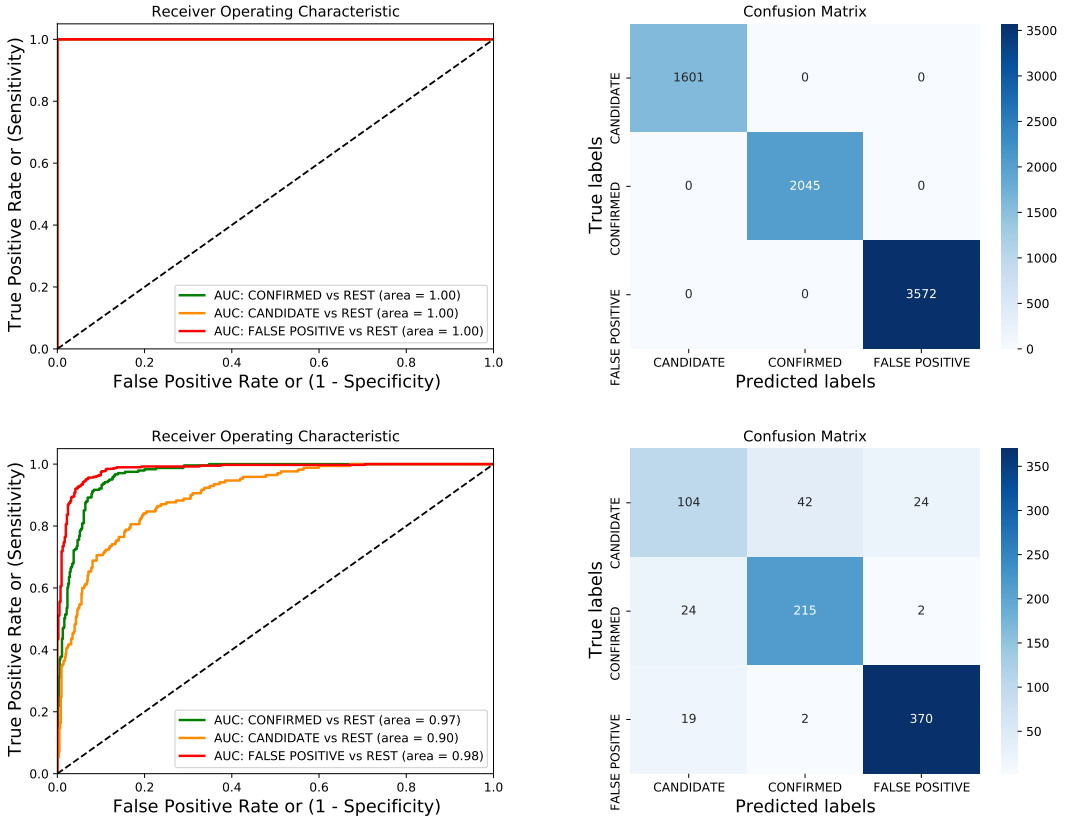


	f1-score	**precision**	**recall**	**support**
CANDIDATE	0.601	0.706	0.524	170.0
CONFIRMED	0.84	0.793	0.892	241.0
FALSE POSITIVE	0.937	0.921	0.954	391.0
accuracy	0.844	0.844	0.844	0.844
macro avg	0.793	0.807	0.79	802.0
weighted avg	0.837	0.837	0.844	802.0

Figure 20: DT: Top Row: overfit test. Middle and bottom row test data

9.1.2 Gradient Boost

The Gradient Boost performance is summarized in Figure 21. 100% recovery is obtained with training data indicating overfitting.

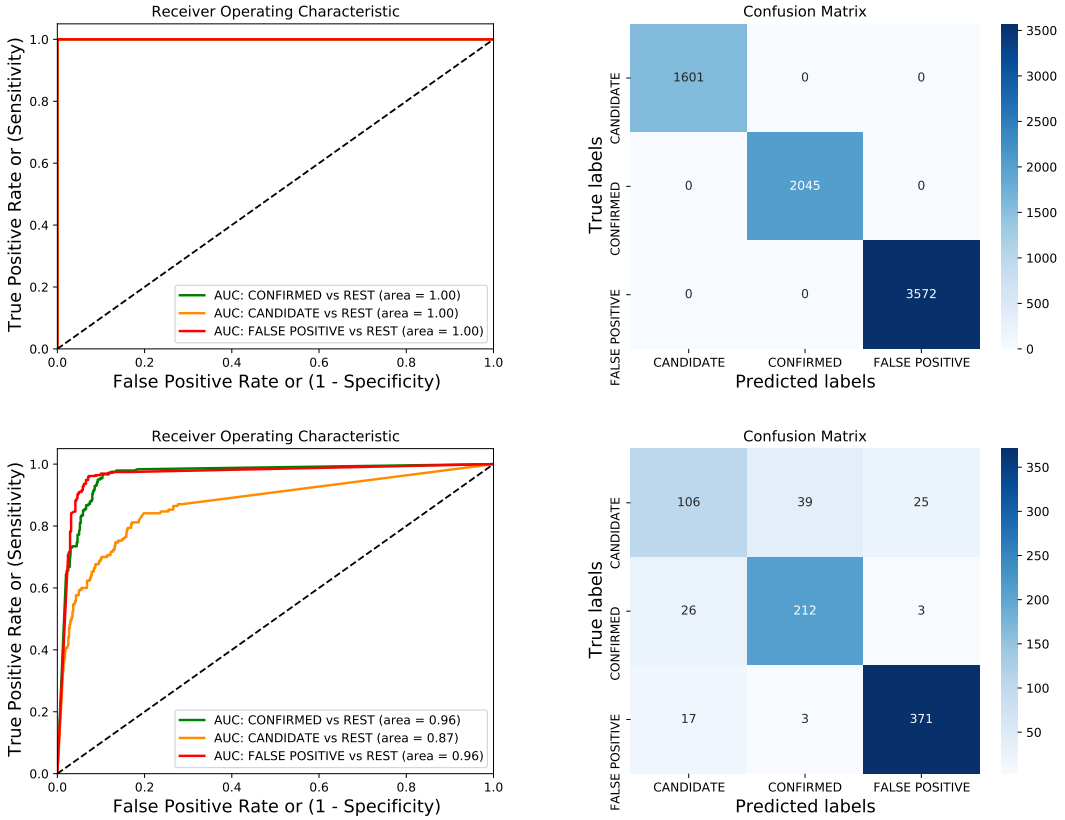


	f1-score	precision	recall	support
CANDIDATE	0.656	0.707	0.612	170.0
CONFIRMED	0.86	0.83	0.892	241.0
FALSE POSITIVE	0.94	0.934	0.946	391.0
accuracy	0.859	0.859	0.859	0.859
macro avg	0.819	0.824	0.817	802.0
weighted avg	0.856	0.855	0.859	802.0

Figure 21: GBvif: Top Row: overfit test. Middle and bottom row test data

9.1.3 Extra Tree Classifier

The Extra Tree Classifier performance is summarized in Figure 22. 100% recovery is obtained with training data indicating overfitting.

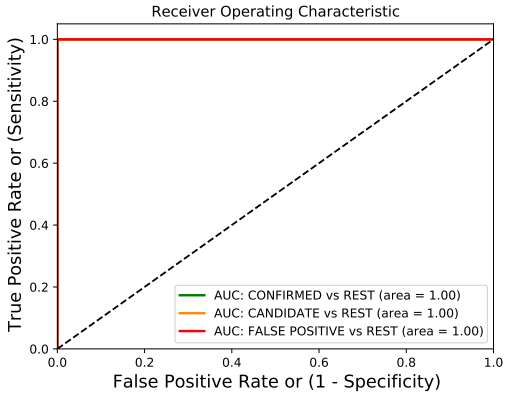


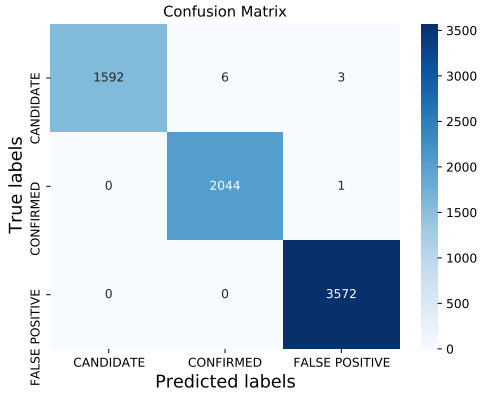
	f1-score	precision	recall	support
CANDIDATE	0.665	0.711	0.624	170.0
CONFIRMED	0.857	0.835	0.88	241.0
FALSE POSITIVE	0.939	0.93	0.949	391.0
accuracy	0.859	0.859	0.859	0.859
macro avg	0.82	0.825	0.817	802.0
weighted avg	0.856	0.855	0.859	802.0

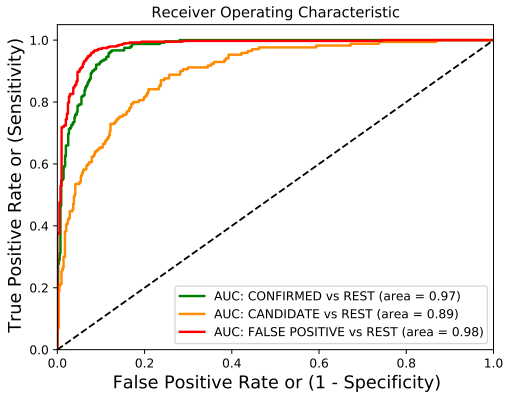
Figure 22: ETvif: Top Row: overfit test. Middle and bottom row test data

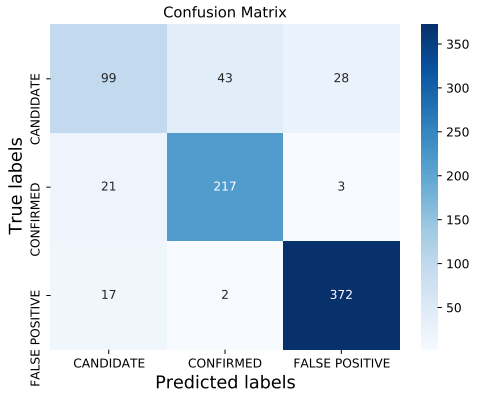
9.1.4 Xtreme Gradient Boost

The Xtreme Gradient Boost performance is summarized in 100% recovery is obtained with training data indicating overfitting.









	f1-score	precision	recall	support
CANDIDATE	0.645	0.723	0.582	170.0
CONFIRMED	0.863	0.828	0.9	241.0
FALSE POSITIVE	0.937	0.923	0.951	391.0
accuracy	0.858	0.858	0.858	0.858
macro avg	0.815	0.825	0.811	802.0
weighted avg	0.853	0.852	0.858	802.0

Figure 23: XGBvifcap2: Top Row: overfit test. Middle and bottom row test data

9.2 Recovery: Treat5.py

Help for Treat5.py is shown in Figure 24 and the options are summarized in Table 11. After recovery eclipsing binaries were removed. [8]. Graphs were generated using matplotlib and a latex report was generated using these graphs see 9.2.1 and 9.2.2. Recovery results not included in the Technical Report are in sections 9.2.1, 9.2.2, 9.2.3 and 9.2.4.

A full list of results comparing four different models was then generated see Table 12 and Table 13

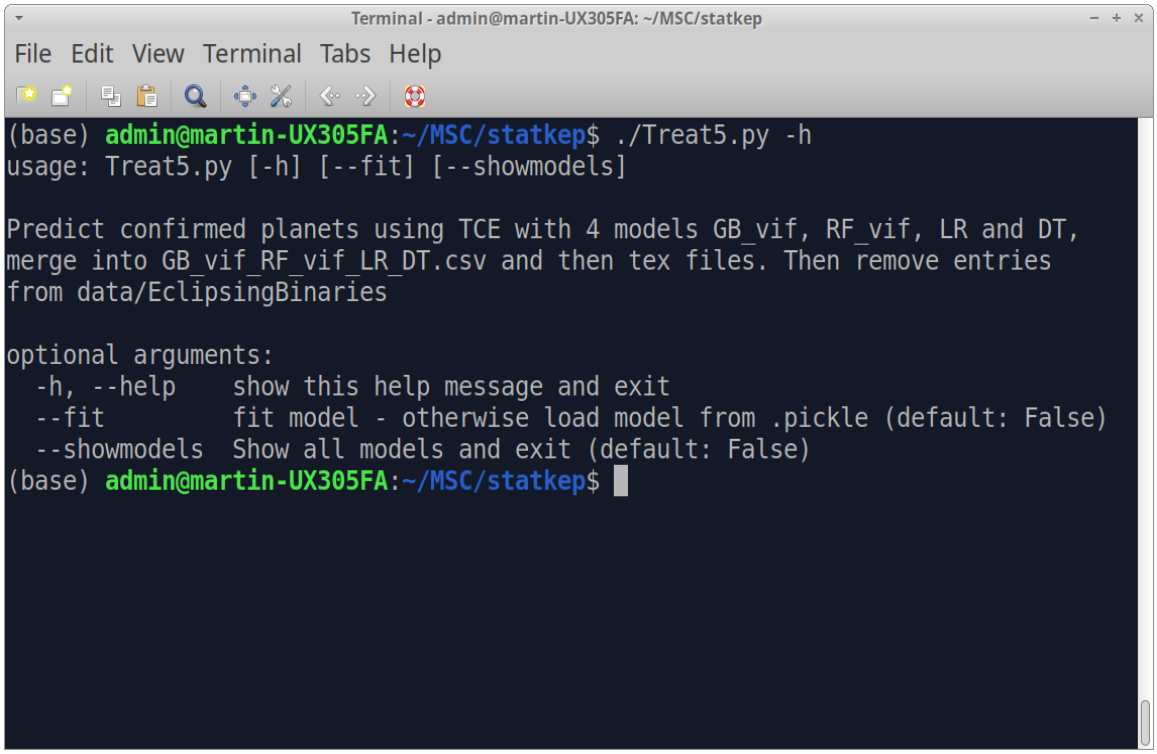


Figure 24: Treat5.py help screen

Table 11: Summary of program Treat5.py

Modification	Reason
fit	By default the model will be loaded from a pickle file but if fit option is called the model will be called and create the pickle file.
showmodels	Show models available
model	Confirmed planets for individual models can be recovered

[8] http://archive.stsci.edu/kepler/eclipsing_binaries.html

9.2.1 Decision Tree

The confirmed planets recovered by Decision Tree are shown in Figure 25.

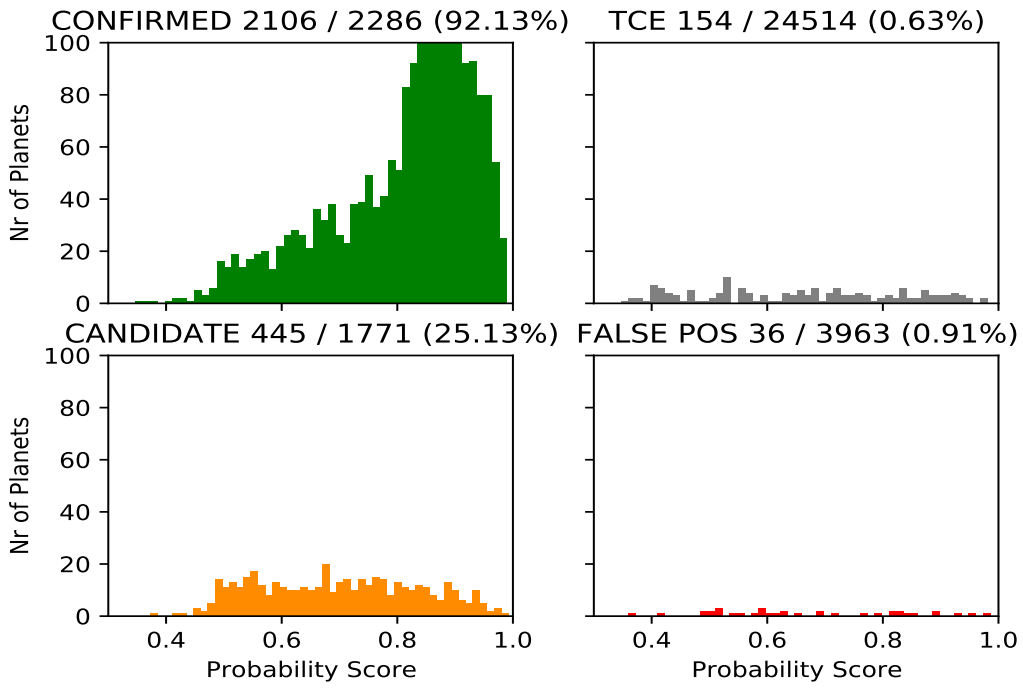


Figure 25: DT: Planets predicted as CONFIRMED

9.2.2 Gradient Boost

The confirmed planets recovered by Gradient Boost are shown in Figure 26.

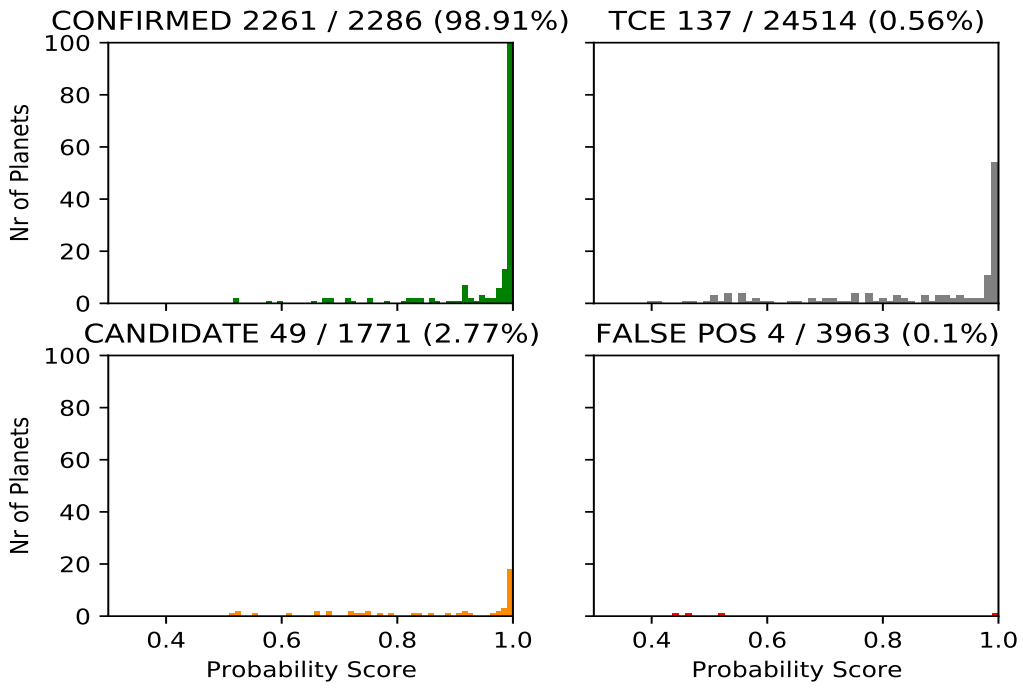


Figure 26: GB_vif: Planets predicted as CONFIRMED

9.2.3 Extra Tree Classifier

The confirmed planets recovered by Extra Tree Classifier are shown in Figure 27.

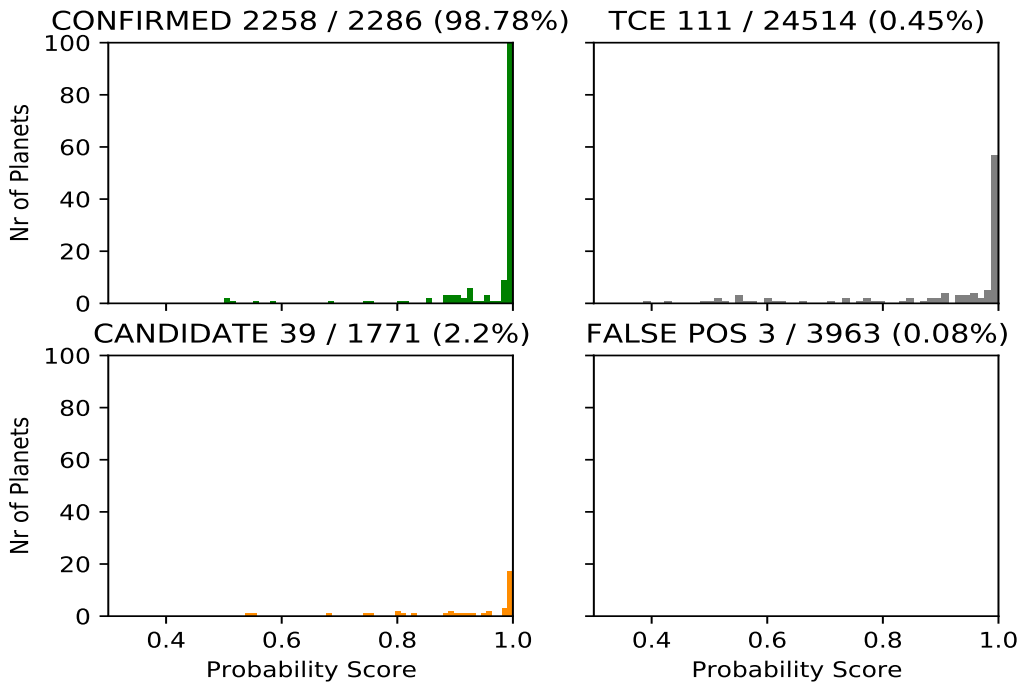


Figure 27: ET_vif: Planets predicted as CONFIRMED

9.2.4 Xtreme Gradient Boost

The confirmed planets recovered by Xtreme Gradient Boost are shown in Figure 28.

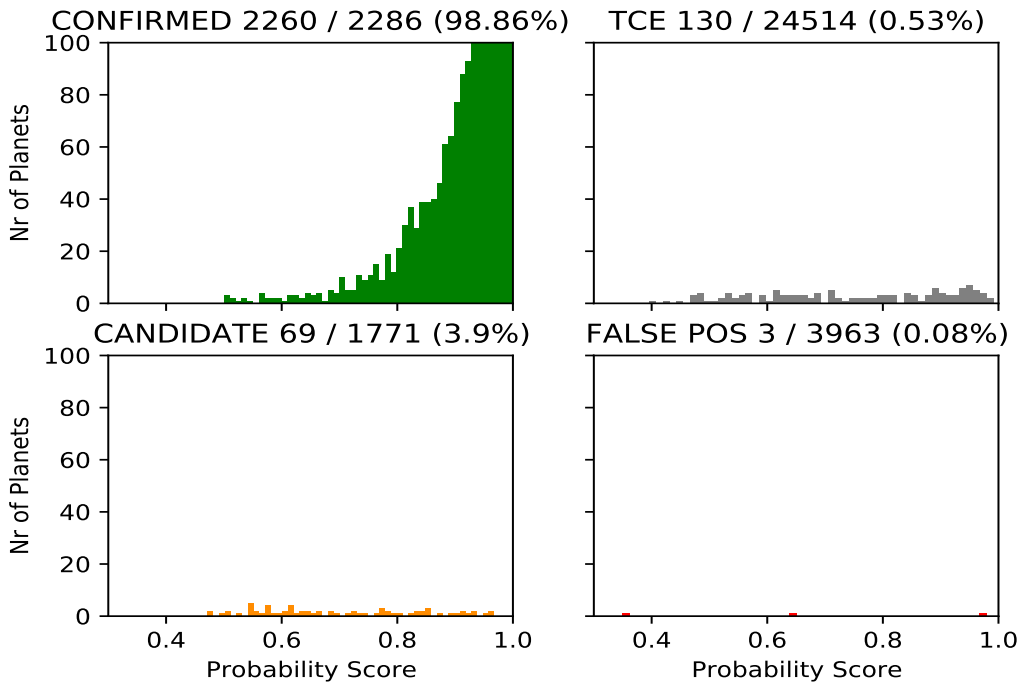


Figure 28: XGB_vif_cap2: Planets predicted as CONFIRMED

9.3 List of recovered planets ordered by Logistic Regression (LR) with eclipsing binaries

Table 12 shows the full list of planets. This table is ordered by Logistic Regression and Eclipsing binaries are marked with 1 under *eb*. The table illustrates that LR and DT mainly return planets from the KOI table with high probability.

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (*eb*=1)

kepid	**plnt num**	**kname**	**dispos**	**LR**	**DT**	**GB_vif**	**RF_vif**	*eb*
8456679	2	K00102.02	FP	0.972	0.951	-	-	0
8480285	1	K00691.01	CAND	0.971	0.948	-	0.503	0
8804455	2	K02159.02	FP	0.963	0.986	-	-	0
10788461	1	K03925.01	CAND	0.959	0.571	-	-	0
9071386	2	-	-	0.956	0.942	1.0	0.843	1
7037540	2	-	-	0.956	0.889	0.999	0.98	1
8552719	2	K01792.02	FP	0.949	0.888	1.0	0.98	1
8644365	1	K03384.01	CAND	0.948	0.943	-	-	0
8804845	1	K02039.01	CAND	0.945	0.919	-	-	0
3831053	1	K00388.01	CAND	0.944	0.966	-	0.642	0
12505076	1	K02154.01	CAND	0.944	0.971	-	-	0
4149450	1	K01864.01	CAND	0.943	0.992	-	-	0
2581316	2	**K03681.02**	CAND	0.942	0.932	1.0	0.952	0
5709725	2	K00555.02	CAND	0.937	0.919	-	0.516	0
3970233	2	-	-	0.935	0.972	0.999	0.97	1
5374854	2	K00645.02	CAND	0.93	0.94	-	-	0
9838975	2	-	-	0.927	0.879	1.0	0.99	1
8180020	2	-	-	0.927	0.925	0.999	0.979	1
3247268	2	K01089.02	CAND	0.927	0.886	-	-	0
11098013	1	K02712.01	CAND	0.924	0.939	-	-	0
9411166	2	-	-	0.921	0.684	0.974	0.979	0
3641726	1	K00804.01	CAND	0.917	0.847	-	-	0
7938496	1	K00900.01	CAND	0.916	0.853	-	-	0
6364215	2	K02404.02	FP	0.915	0.82	-	-	0
5972334	2	K00191.02	CAND	0.915	0.933	-	-	0
10794087	1	K01316.01	CAND	0.914	0.899	1.0	0.959	0
8934495	1	K00524.01	CAND	0.91	0.689	-	-	0
11566064	2	K00353.02	CAND	0.909	0.809	-	-	0
9446824	2	-	-	0.908	0.913	0.999	0.979	1
11030475	1	K02248.01	CAND	0.907	0.875	-	-	0
8176650	2	-	-	0.905	0.874	1.0	0.971	0
9605514	1	K00945.01	CAND	0.905	0.893	-	-	0
12504988	2	-	-	0.905	0.921	1.0	0.969	1
3342592	2	-	-	0.904	0.935	0.998	0.949	1
9605514	2	K00945.02	CAND	0.903	0.85	-	-	0
5965819	1	K03319.01	CAND	0.903	0.89	-	0.508	1

Continued on next page

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

5531953	1	K01681.01	CAND	0.903	0.844	-	-	0
5972334	3	K00191.03	CAND	0.9	0.935	-	-	0
3642741	1	K00242.01	FP	0.899	0.852	-	-	0
10867062	1	K01303.01	CAND	0.896	0.901	-	-	0
5794570	2	K02675.02	CAND	0.896	0.764	-	-	0
9823487	1	K01489.01	CAND	0.894	0.882	-	-	0
11187837	1	K00252.01	CAND	0.893	0.862	-	-	1
8495415	1	K02362.01	FP	0.892	-	-	-	1
6762829	2	-	-	0.892	0.839	0.999	0.96	1
9266431	1	K00704.01	CAND	0.89	0.9	-	-	0
11071200	2	K02696.02	CAND	0.887	0.858	-	-	0
5770074	1	K01928.01	CAND	0.887	0.719	-	-	0
2853780	1	K02081.01	CAND	0.885	0.943	-	-	0
5792202	3	K00841.03	CAND	0.884	0.832	-	-	0
9150827	1	K01408.01	CAND	0.883	0.865	-	0.505	0
4851464	2	-	-	0.883	0.923	0.999	0.929	1
8613535	1	K02263.01	CAND	0.88	0.907	-	-	0
5031857	2	K01573.02	CAND	0.879	0.584	-	0.967	0
5374838	1	K05155.01	CAND	0.877	0.66	-	-	0
5342473	1	K02297.01	CAND	0.875	0.818	-	-	0
8073806	1	K02411.01	CAND	0.873	0.899	-	-	0
5211199	1	K02158.01	CAND	0.873	0.92	-	-	0
11297236	1	K01857.01	CAND	0.872	0.686	-	-	0
5031857	1	K01573.01	CAND	0.871	0.676	-	-	0
7697568	1	K01829.01	FP	0.869	-	-	-	0
9006186	2	K02169.02	CAND	0.868	0.886	-	-	0
11874577	1	K02779.01	CAND	0.868	0.845	-	-	0
2438513	1	K01944.01	CAND	0.867	0.952	-	-	0
9592705	1	K00288.01	CAND	0.867	0.734	-	-	1
6049190	1	K01685.01	CAND	0.867	0.564	-	-	0
11709124	2	-	-	0.867	0.938	1.0	0.918	0
5035972	2	-	-	0.866	0.561	0.75	0.903	1
5370302	2	-	-	0.866	0.908	1.0	0.971	1
5020319	1	K00635.01	CAND	0.866	0.912	-	0.508	0
3940418	1	K00810.01	CAND	0.866	0.824	-	-	0
11404644	2	-	-	0.865	0.956	0.962	-	1
6946199	2	K01359.02	CAND	0.865	0.759	-	-	0
7670943	1	K00269.01	CAND	0.864	0.904	-	-	0
2449431	1	K02009.01	CAND	0.861	0.863	0.984	0.931	0
10710755	2	-	-	0.86	0.903	0.716	0.389	1
10676824	1	K00599.01	CAND	0.859	0.77	-	-	0
5786676	1	K00650.01	CAND	0.858	0.811	0.999	0.949	0
9632895	2	-	-	0.856	0.742	1.0	0.462	1
11810124	1	K03344.01	CAND	0.854	0.761	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

6383785	2	K00239.02	CAND	0.853	0.853	-	-	0
5195172	1	K01671.01	CAND	0.85	0.978	-	-	0
10134152	1	K02056.01	CAND	0.85	0.906	-	-	0
10016874	1	K00426.01	CAND	0.85	0.809	0.717	0.96	0
11071200	1	K02696.01	CAND	0.848	0.633	-	-	0
10904857	2	-	-	0.845	0.879	0.994	0.96	1
9117416	2	K03425.02	CAND	0.845	0.841	-	-	1
11408935	2	-	-	0.843	0.898	0.994	0.915	1
4770365	2	K01475.02	CAND	0.843	0.785	-	-	0
7887791	1	K01964.01	CAND	0.841	-	-	-	0
7364176	1	K00373.01	CAND	0.84	0.679	-	-	0
9006186	3	K02169.03	CAND	0.838	0.893	-	-	0
9904006	2	K02135.02	CAND	0.837	0.746	-	-	0
3097926	1	K02186.01	CAND	0.837	0.804	0.985	0.959	0
11026304	1	K01420.01	CAND	0.836	-	-	-	0
3128552	3	K02055.03	CAND	0.834	0.77	-	-	0
11337141	1	K01649.01	CAND	0.832	-	-	-	0
7899070	1	K02683.01	CAND	0.832	0.838	-	-	0
5534941	1	K02332.01	CAND	0.83	0.969	1.0	0.929	0
4365645	1	K01738.01	CAND	0.83	0.884	-	-	0
9244756	1	K01969.01	CAND	0.83	0.848	-	-	0
10395543	1	K00531.01	CAND	0.829	0.907	-	-	1
9636135	2	K01498.02	CAND	0.828	-	-	-	0
6587002	3	K00612.03	CAND	0.826	0.855	-	-	0
6698670	2	-	-	0.826	0.84	0.997	0.849	1
7948784	1	K01968.01	CAND	0.823	0.708	-	-	0
3102000	2	-	-	0.822	0.913	0.999	0.898	1
11705004	1	K02199.01	CAND	0.822	0.544	-	-	0
9837661	3	K02715.03	CAND	0.82	0.75	-	-	0
8460600	2	-	-	0.82	0.817	0.992	0.565	1
12017109	1	K02106.01	CAND	0.819	0.848	-	-	0
11599038	1	K01437.01	CAND	0.819	0.896	-	-	0
8263545	1	K02822.01	CAND	0.819	0.888	0.991	0.939	0
5376836	2	-	-	0.819	0.869	0.999	0.98	1
9288786	2	-	-	0.819	0.896	1.0	0.909	1
4466677	2	K01338.02	CAND	0.817	0.526	-	-	0
11030475	2	-	-	0.816	0.736	0.999	0.907	0
10485250	2	-	-	0.814	0.761	-	0.538	1
3109930	1	K01112.01	CAND	0.814	0.795	-	-	0
5219234	3	K01563.03	CAND	0.813	0.644	-	-	0
11852982	1	K00247.01	CAND	0.812	0.838	-	-	0
7256914	1	K04136.01	CAND	0.811	0.949	-	-	0
9649222	2	-	-	0.81	0.862	0.988	0.915	1
8892910	2	-	-	0.809	0.591	0.998	0.978	1

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

5384713	1	K03444.01	CAND	0.809	-	-	-	1
11568987	2	K00354.02	CAND	0.805	0.741	-	-	1
7584650	1	K02631.01	CAND	0.805	0.885	1.0	0.96	0
8686150	2	-	-	0.805	0.89	0.935	0.643	1
7679812	1	K03943.01	CAND	0.804	0.864	-	-	0
9896018	2	K02579.02	CAND	0.804	0.726	-	-	0
7975727	2	-	-	0.804	0.852	0.999	0.96	1
9697131	1	K02706.01	CAND	0.803	0.682	0.679	0.736	0
5042210	1	K02462.01	CAND	0.803	0.967	0.92	0.918	0
8043714	2	-	-	0.803	0.838	-	0.929	1
11752906	1	K00253.01	CAND	0.803	0.795	-	-	0
9532710	1	K02364.01	FP	0.802	0.716	-	-	0
11853878	2	K01833.02	CAND	0.802	-	-	-	0
9896018	1	K02579.01	CAND	0.8	0.887	-	-	0
7386827	1	K01704.01	CAND	0.799	0.81	-	-	0
8078502	1	K03383.01	CAND	0.798	0.923	-	-	0
7023960	2	-	-	0.798	0.859	0.996	0.957	1
4164922	1	K03864.01	CAND	0.797	0.668	-	-	0
8552202	1	K00914.01	CAND	0.796	-	-	-	0
10287248	2	-	-	0.795	0.892	0.995	0.84	1
12120943	1	K01458.01	CAND	0.793	0.748	-	-	0
11821363	1	K01494.01	CAND	0.792	0.8	-	-	0
10587105	3	K00339.03	CAND	0.791	0.55	-	-	0
7983117	1	K03214.01	CAND	0.791	-	-	-	0
5780885	2	-	-	0.787	0.607	0.912	0.4	0
9405595	1	K02125.01	CAND	0.787	0.822	-	-	0
10713616	1	K01311.01	CAND	0.784	0.648	-	-	0
5601258	1	K02191.01	CAND	0.784	0.8	-	-	0
8558011	1	K00577.01	CAND	0.784	0.777	-	-	0
9595686	1	K00944.01	CAND	0.783	0.767	-	-	0
3663173	1	K02750.01	CAND	0.783	0.616	-	-	0
10875007	1	K04149.01	CAND	0.781	0.76	-	-	0
9269281	1	K01398.01	CAND	0.781	-	-	-	0
3734868	2	-	-	0.778	0.643	1.0	0.99	1
8578780	1	K02023.01	CAND	0.778	0.888	-	-	0
10091110	3	-	-	0.778	0.742	0.999	0.947	1
8505920	1	K02094.01	CAND	0.777	0.835	-	-	0
11126381	1	K01863.01	CAND	0.776	0.889	0.999	0.933	0
11030711	1	K01429.01	CAND	0.776	0.585	-	-	0
11074178	2	K01889.02	CAND	0.775	0.896	-	-	0
5356593	2	-	-	0.775	0.839	0.77	0.948	1
9579641	3	K00115.03	CAND	0.774	-	-	-	0
4770365	1	K01475.01	CAND	0.773	0.832	-	-	0
7733731	1	K04022.01	CAND	0.771	0.944	-	-	1

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

9267996	1	K03431.01	FP	0.771	-	-	-	0
8458207	2	-	-	0.77	0.758	0.979	-	1
5953297	1	K02733.01	CAND	0.767	0.865	-	-	0
12469800	1	K02543.01	CAND	0.764	0.679	-	-	0
5872150	3	-	-	0.764	0.777	0.99	0.922	1
6198182	1	K02636.01	CAND	0.764	0.782	-	-	0
4242147	1	K01934.01	CAND	0.761	0.803	0.909	0.929	0
4951877	1	K00501.01	CAND	0.761	0.841	-	-	0
10877367	2	-	-	0.758	-	-	-	0
9517393	1	K02076.01	CAND	0.758	0.491	-	-	0
9772531	1	K00950.01	CAND	0.757	0.77	-	-	1
10350571	2	K01175.02	CAND	0.757	0.785	-	-	0
5629353	1	K06132.01	CAND	0.755	-	-	-	1
8261920	3	K02174.03	CAND	0.755	0.549	-	-	0
11253711	1	K01972.01	CAND	0.754	0.785	-	-	0
7202957	2	K02687.02	CAND	0.754	0.952	-	-	0
6467363	1	K02840.01	CAND	0.753	0.682	-	-	0
4756776	2	-	-	0.752	0.441	-	-	0
11967788	1	K04021.01	CAND	0.752	0.75	-	-	0
3425851	1	K00268.01	CAND	0.752	0.851	-	-	0
11656840	2	-	-	0.75	-	-	-	1
8780959	2	K03741.02	FP	0.75	0.831	-	-	0
10294509	1	K04143.01	FP	0.75	-	-	-	0
11657614	1	K03370.01	CAND	0.749	0.758	-	-	0
6058816	1	K03500.01	CAND	0.749	0.836	-	-	0
5978361	1	K00558.01	CAND	0.746	0.738	-	-	0
7877978	1	K02760.01	CAND	0.745	0.809	-	-	0
10793172	2	K02871.02	CAND	0.743	0.723	-	-	0
11026582	1	K05854.01	CAND	0.742	-	-	-	0
2854181	1	K02232.01	CAND	0.742	0.821	-	-	0
5384713	2	K03444.02	FP	0.741	0.69	-	-	1
12120307	3	K02597.03	CAND	0.741	0.618	-	-	0
7135852	1	K00875.01	CAND	0.74	0.767	-	-	0
9230021	1	K03429.01	CAND	0.739	0.735	-	-	0
5384713	3	K03444.03	CAND	0.736	0.661	-	-	1
8678594	2	K01261.02	CAND	0.736	0.863	-	-	0
3098810	1	K01878.01	CAND	0.733	0.584	-	-	0
10616571	3	-	-	0.731	0.724	1.0	0.96	1
6342333	1	K02065.01	CAND	0.728	0.733	-	-	0
6666233	2	-	-	0.727	0.837	1.0	0.846	0
9729691	2	K01751.02	FP	0.726	-	-	-	0
3859628	1	K01191.01	CAND	0.724	0.788	-	-	0
7449554	1	K02357.01	CAND	0.723	0.79	0.92	0.863	0
10793172	1	K02871.01	CAND	0.721	0.758	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

10319385	1	K01169.01	CAND	0.72	0.751	-	-	0
5787131	1	K02927.01	CAND	0.72	0.766	-	-	0
8564976	1	K03890.01	CAND	0.716	-	-	-	0
6803202	1	K00177.01	CAND	0.714	0.91	-	0.503	0
4860678	1	K01602.01	CAND	0.714	0.741	-	-	0
7183745	2	K02521.02	CAND	0.714	0.855	-	-	0
7287415	1	K01369.01	CAND	0.713	0.937	-	-	0
11718144	1	K02310.01	CAND	0.713	0.833	-	-	0
6719086	1	K01357.01	CAND	0.713	0.715	-	-	0
11244682	1	K03933.01	CAND	0.712	0.882	-	-	0
9414417	1	K00974.01	CAND	0.712	-	-	-	0
10513530	2	K00533.02	CAND	0.712	-	-	-	0
10923260	2	-	-	0.711	0.656	0.979	0.556	1
12785320	2	K00298.02	CAND	0.71	0.729	-	-	0
10973664	2	K00601.02	CAND	0.709	-	-	-	0
9030537	1	K01892.01	CAND	0.707	0.545	-	-	0
4857213	1	K02120.01	CAND	0.706	0.74	-	-	0
4548098	1	K04157.01	CAND	0.705	0.831	-	-	0
3761319	1	K06104.01	CAND	0.704	0.689	-	-	0
5716932	1	K02358.01	CAND	0.703	0.778	-	-	0
10252275	2	K03130.02	CAND	0.703	0.646	-	-	0
12105051	1	K00141.01	CAND	0.703	0.762	-	-	0
7941200	1	K00092.01	CAND	0.702	-	-	-	0
11754430	2	K03403.02	CAND	0.7	0.699	-	-	0
10337517	1	K01165.01	CAND	0.697	0.88	-	0.516	0
2446113	1	K00379.01	FP	0.697	0.927	-	-	0
12156347	1	K02588.01	CAND	0.696	0.718	-	-	0
5542466	1	K01590.01	CAND	0.695	-	-	-	0
6614926	2	-	-	0.693	0.718	0.778	-	1
5978559	1	K02321.01	CAND	0.693	0.698	0.992	0.959	0
10118816	1	K01085.01	CAND	0.693	0.826	-	-	0
7287683	1	K01622.01	CAND	0.692	0.715	-	-	0
11752906	2	K00253.02	CAND	0.691	0.712	-	-	0
8257205	2	K01986.02	CAND	0.691	0.727	-	-	0
12121570	1	K02290.01	CAND	0.691	0.685	-	-	0
8655354	2	-	-	0.691	0.726	0.736	0.5	0
9836959	1	K01715.01	CAND	0.69	0.55	0.977	0.938	0
9934208	2	-	-	0.69	0.876	1.0	0.853	1
10055126	3	K01608.03	CAND	0.689	0.534	-	-	0
7294743	1	K02516.01	CAND	0.688	0.874	-	-	0
5531953	2	K01681.02	FP	0.688	0.833	-	-	0
10387742	1	K02583.01	CAND	0.688	0.9	-	-	0
11599264	2	-	-	0.688	-	-	-	1
7522911	1	K01705.01	CAND	0.688	0.707	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

6956216	2	-	-	0.687	-	-	-	1
12061238	1	K01502.01	FP	0.687	-	-	-	0
10514430	3	-	-	0.685	0.726	-	0.385	0
6975129	3	K01628.03	FP	0.685	0.586	-	-	0
4862625	2	-	-	0.685	-	1.0	0.429	1
7362696	2	-	-	0.685	0.766	0.888	0.895	1
9700449	1	K04120.01	CAND	0.684	-	-	-	0
9489524	4	K02029.04	CAND	0.683	0.489	-	-	0
10363115	1	K03908.01	CAND	0.682	0.781	-	-	0
11138155	1	K00760.01	CAND	0.681	0.656	-	-	1
8494542	1	K02204.01	CAND	0.679	0.679	-	-	0
10386922	1	K00289.01	CAND	0.679	0.631	-	-	0
11771430	1	K02582.01	CAND	0.679	0.689	-	-	0
3323887	2	-	-	0.677	0.714	0.805	-	0
9692128	1	K02769.01	FP	0.677	-	-	-	0
10418797	2	-	-	0.677	0.713	1.0	0.922	1
11462341	1	K02124.01	CAND	0.677	0.686	-	-	0
11442465	2	-	-	0.677	-	-	-	1
8018547	1	K00902.01	CAND	0.676	0.742	-	-	0
6543893	2	K01627.02	CAND	0.674	0.754	-	-	0
8074805	2	-	-	0.674	0.633	0.999	0.791	1
6609270	1	K03090.01	CAND	0.674	0.727	-	-	0
11192235	1	K02329.01	CAND	0.673	0.599	-	0.888	0
9489524	3	K02029.03	CAND	0.673	-	-	-	0
5283542	1	K00827.01	FP	0.673	-	-	-	0
11922778	1	K03408.01	CAND	0.671	-	-	-	0
3229150	1	K02150.01	CAND	0.671	-	-	-	0
9898447	1	K02803.01	CAND	0.668	0.832	-	-	0
8261920	2	K02174.02	CAND	0.668	0.549	-	-	0
8984831	4	-	-	0.667	-	-	-	0
6721523	5	-	-	0.667	0.462	-	-	0
5480766	5	-	-	0.666	-	-	-	0
10074466	1	K01917.01	CAND	0.663	0.606	-	-	0
5980783	1	K02967.01	CAND	0.663	0.662	0.854	0.968	0
9700145	4	-	-	0.661	0.474	-	-	0
5629353	3	K06132.03	CAND	0.66	0.791	-	-	1
8162789	1	K00521.01	CAND	0.659	-	-	0.457	0
4547480	2	-	-	0.659	0.53	-	-	1
7202957	1	K02687.01	CAND	0.657	-	-	-	0
6862721	1	K01982.01	CAND	0.657	0.746	-	-	0
8630788	3	K01258.03	CAND	0.657	0.494	-	-	0
11818607	1	K02467.01	CAND	0.656	0.567	-	-	0
3757778	2	-	-	0.655	0.805	0.933	-	1
4650733	1	K01659.01	CAND	0.655	0.585	0.747	0.913	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

10158418	1	K01784.01	CAND	0.655	0.699	-	-	1
12061969	2	K02061.02	CAND	0.654	-	-	-	0
9528430	2	-	-	0.654	-	-	-	1
4814502	1	K04004.01	CAND	0.653	0.869	1.0	0.969	0
9346253	2	-	-	0.653	0.828	0.995	0.83	1
11968463	3	K02433.03	CAND	0.653	-	0.997	-	0
3561464	3	K03398.03	CAND	0.652	0.494	-	-	0
9307509	1	K02096.01	CAND	0.652	0.857	-	-	0
8410415	1	K02291.01	CAND	0.651	0.773	-	-	0
6805146	2	-	-	0.651	0.736	0.869	0.79	1
7700622	1	K00315.01	CAND	0.651	0.708	-	-	0
3937519	2	K00221.02	CAND	0.649	0.824	-	-	0
10397751	3	K02859.03	CAND	0.648	-	-	-	0
10621643	5	-	-	0.647	0.396	-	-	0
10141900	1	K01082.01	CAND	0.645	0.694	-	-	0
10252275	1	K03130.01	CAND	0.644	0.8	-	-	0
9458754	4	-	-	0.642	0.411	-	-	0
8394756	3	-	-	0.642	-	-	-	0
2447832	5	-	-	0.642	0.421	-	-	0
11122789	4	-	-	0.64	-	-	-	1
3561464	2	K03398.02	CAND	0.639	0.669	-	-	0
11967788	2	K04021.02	CAND	0.639	0.585	-	-	0
4846856	1	K02900.01	CAND	0.638	-	-	-	0
9995771	1	K03470.01	CAND	0.636	0.821	1.0	0.957	0
10189546	1	K00427.01	CAND	0.636	-	-	-	0
7289577	1	K01974.01	CAND	0.635	0.566	-	-	0
11076400	1	K02759.01	CAND	0.634	0.535	-	-	0
12115188	2	-	-	0.633	0.792	1.0	0.462	0
12406807	1	K03091.01	CAND	0.633	0.601	-	-	0
9100953	2	K04500.02	CAND	0.632	-	-	-	0
11122894	3	K01426.03	CAND	0.632	0.831	-	-	0
5966810	1	K03909.01	CAND	0.631	0.599	0.528	0.87	0
7219825	3	K00238.03	CAND	0.631	0.58	-	-	0
7661065	1	K02307.01	CAND	0.63	0.571	-	-	0
10464078	2	-	-	0.63	0.551	1.0	0.871	1
8747865	5	-	-	0.63	-	-	-	0
6955650	1	-	-	0.629	0.518	-	-	0
7377343	1	K05384.01	CAND	0.629	0.813	-	-	1
2832589	1	K01942.01	CAND	0.628	-	-	-	0
11601584	3	K01831.03	CAND	0.627	-	-	-	1
5621333	1	K03341.01	CAND	0.627	0.646	-	-	0
9475552	2	K02694.02	CAND	0.627	0.711	-	-	0
11189127	2	-	-	0.625	0.768	0.948	0.864	1
8074328	1	K02486.01	CAND	0.623	-	-	-	0

Continued on next page

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

6356692	1	K02948.01	CAND	0.622	0.809	-	-	0
7124026	1	K02275.01	FP	0.621	0.791	-	-	0
8247770	1	K02569.01	CAND	0.621	0.703	-	-	0
12268190	7	-	-	0.621	-	-	-	0
8580438	2	-	-	0.62	0.705	0.846	-	1
10865397	4	-	-	0.62	-	-	-	0
5080636	2	K01843.02	CAND	0.619	-	-	-	0
5905822	1	K02801.01	CAND	0.617	0.682	-	-	0
9958962	3	K00593.03	CAND	0.617	-	-	-	0
9654468	1	K02417.01	CAND	0.615	0.615	-	-	0
1571511	2	-	-	0.614	0.666	0.999	0.979	1
10470206	1	K00335.01	FP	0.613	-	-	-	0
10186945	2	-	-	0.612	0.657	0.837	0.823	1
3634051	1	K06103.01	FP	0.612	0.587	-	-	0
6115603	3	-	-	0.612	0.403	-	-	0
6605493	1	K02559.01	CAND	0.612	0.731	-	-	0
9140402	1	K00928.01	CAND	0.612	0.935	-	-	1
2164169	1	K01029.01	CAND	0.612	0.744	-	-	0
4947556	1	K03936.01	FP	0.611	-	-	-	0
3629967	1	K01901.01	CAND	0.61	0.614	-	-	0
8321314	1	K02293.01	CAND	0.61	0.699	-	-	0
7678434	2	K00892.02	CAND	0.61	0.522	-	-	1
10525049	1	K04252.01	CAND	0.61	0.806	-	-	0
10656508	1	K00211.01	CAND	0.61	-	-	-	1
9153823	1	K06195.01	FP	0.608	0.817	-	-	0
3120650	5	-	-	0.608	0.38	-	-	0
10028140	1	K01591.01	CAND	0.608	0.636	-	-	0
6428794	1	K04054.01	CAND	0.607	0.847	0.999	0.914	0
5441980	1	K00607.01	CAND	0.606	0.802	-	-	0
9472000	1	K02082.01	CAND	0.606	0.541	-	-	0
8492101	1	K04437.01	FP	0.606	-	-	-	0
8013439	3	K02352.03	CAND	0.604	0.778	-	-	1
8397947	1	K04772.01	CAND	0.604	-	-	-	0
12737015	1	K04245.01	CAND	0.604	-	-	-	0
2161536	1	K02130.01	CAND	0.603	0.674	-	-	0
10744342	4	-	-	0.603	0.558	-	-	0
7879433	1	K02527.01	CAND	0.603	0.632	-	-	0
7987866	1	K02363.01	CAND	0.601	0.728	-	-	0
8261920	1	K02174.01	CAND	0.601	0.503	-	-	0
5131180	1	K00641.01	CAND	0.601	0.641	-	-	0
7050754	2	-	-	0.601	-	-	-	0
1872821	1	K02351.01	CAND	0.599	0.579	-	-	0
4770174	1	K02971.01	CAND	0.598	0.747	-	-	0
8709688	1	K03019.01	CAND	0.598	0.709	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

3323887	3	-	-	0.598	0.42	0.999	-	0
7120108	1	K02325.01	CAND	0.597	0.602	-	-	0
2718778	1	K02489.01	CAND	0.596	-	0.998	0.857	0
8189801	1	K02480.01	CAND	0.596	0.655	-	-	0
10460984	3	K00474.03	CAND	0.595	-	-	-	0
8823868	2	-	-	0.595	0.705	0.835	0.406	1
9017682	1	K01630.01	CAND	0.593	0.648	-	-	0
6359320	3	K01127.03	CAND	0.593	-	-	-	0
9334893	1	K02298.01	CAND	0.593	0.492	-	-	0
8110767	1	K02504.01	CAND	0.592	0.514	-	-	0
9451127	2	-	-	0.592	0.678	-	0.353	1
11818872	1	K02581.01	CAND	0.592	0.803	-	-	0
3218908	4	-	-	0.591	0.626	0.585	0.514	0
10614158	2	-	-	0.591	-	-	-	1
4851530	1	K01884.01	FP	0.591	-	-	-	0
4157325	3	K01860.03	CAND	0.59	-	-	-	0
5213230	1	K03474.01	CAND	0.59	0.72	0.748	0.933	0
1722916	6	-	-	0.59	-	-	-	0
7826659	1	K02686.01	CAND	0.59	0.584	-	-	0
7869917	2	K01525.02	CAND	0.589	-	-	-	0
10092312	1	K01823.01	FP	0.589	-	-	-	0
9283002	3	-	-	0.588	0.431	-	-	0
4771030	3	-	-	0.588	-	-	-	0
5556241	4	-	-	0.587	-	-	-	0
5942808	2	K02250.02	CAND	0.585	-	-	-	0
4385148	2	K02942.02	CAND	0.585	0.498	-	-	0
7463685	1	K02890.01	CAND	0.583	0.674	-	-	0
3103212	1	K04145.01	CAND	0.583	0.841	-	-	0
10028352	1	K01957.01	CAND	0.583	0.74	-	-	1
6871071	4	K02220.04	CAND	0.582	0.589	-	-	0
5942808	1	K02250.01	CAND	0.581	-	-	-	0
7199397	1	K00075.01	CAND	0.581	-	-	-	0
12457978	6	-	-	0.581	-	-	-	0
6867588	1	K02571.01	CAND	0.58	0.805	-	-	0
4173026	1	K02172.01	CAND	0.579	0.778	-	-	0
4473226	1	K02229.01	CAND	0.579	0.802	-	-	0
7375348	2	K00266.02	CAND	0.579	0.645	0.993	0.846	1
6110119	8	-	-	0.578	-	-	-	0
12406749	1	K01476.01	CAND	0.577	0.923	-	-	0
3122913	1	K02490.01	CAND	0.576	0.636	-	-	0
4548011	2	K04288.02	CAND	0.575	0.601	-	-	0
5436013	1	K02471.01	CAND	0.575	0.872	-	-	0
8753896	2	-	-	0.574	0.528	0.555	-	0
9714123	2	-	-	0.573	0.755	0.966	0.429	1

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

11395587	1	K00350.01	CAND	0.573	0.907	-	-	0
9691311	4	-	-	0.572	-	-	-	0
10533616	3	-	-	0.571	-	-	-	0
9936080	1	K04431.01	CAND	0.57	0.554	-	-	0
9205938	2	K02162.02	CAND	0.57	-	-	-	0
7017372	1	K03689.01	CAND	0.569	-	-	-	0
10583180	2	-	-	0.569	-	-	-	1
7017274	1	K03209.01	CAND	0.569	0.641	-	-	0
10471621	1	K02554.01	CAND	0.568	0.499	-	-	0
9003401	1	K02319.01	CAND	0.567	-	-	-	0
9714572	8	-	-	0.567	-	-	-	0
9328641	2	-	-	0.567	-	-	-	0
6837283	1	K02914.01	CAND	0.567	-	-	-	0
9002538	2	K03196.02	CAND	0.566	-	-	-	0
9993529	1	K02644.01	FP	0.565	-	-	-	0
11968463	4	K02433.04	CAND	0.565	0.49	-	-	0
2444412	1	K00103.01	CAND	0.565	0.459	0.924	-	0
7137725	1	K01699.01	FP	0.564	0.574	-	-	0
3231341	5	-	-	0.564	0.555	0.894	0.877	0
8480582	1	K04386.01	CAND	0.561	0.91	-	-	0
5621333	2	K03341.02	CAND	0.561	0.557	-	-	0
12170648	2	-	-	0.56	-	0.783	0.429	1
10122538	5	K02926.05	CAND	0.559	0.673	-	-	0
6579806	2	-	-	0.558	-	-	-	1
10875007	2	K04149.02	CAND	0.558	-	-	-	0
8056665	2	K00089.02	CAND	0.558	0.55	-	-	0
7256914	2	K04136.02	CAND	0.557	0.678	-	-	0
5906694	1	K04069.01	CAND	0.557	0.556	-	-	0
3239671	1	K02066.01	CAND	0.557	0.515	-	-	0
8540376	1	K07892.01	CAND	0.557	0.577	-	-	0
4058206	3	-	-	0.555	-	-	-	0
11394027	1	K00349.01	CAND	0.554	0.931	-	-	0
8240861	4	-	-	0.553	-	-	-	1
8554498	1	K00005.01	CAND	0.553	-	-	-	1
7825899	3	K00896.03	CAND	0.553	-	-	-	0
5471059	2	K03956.02	FP	0.553	-	-	-	0
11548140	1	K00256.01	FP	0.552	0.658	-	-	1
7749773	1	K02848.01	CAND	0.552	0.634	-	-	0
8684730	1	K00319.01	CAND	0.551	0.575	-	-	0
9872292	1	K01537.01	CAND	0.551	0.704	-	-	0
6606438	1	K02860.01	CAND	0.551	-	-	-	0
12602335	3	-	-	0.551	-	-	-	0
5775129	1	K02802.01	CAND	0.551	0.719	0.972	0.947	0
10005758	2	K01783.02	CAND	0.55	0.548	0.993	0.737	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

5881120	1	K04156.01	CAND	0.55	0.621	-	-	0
5552761	7	-	-	0.55	-	-	-	0
4140813	1	K02117.01	CAND	0.549	0.779	-	-	0
5773121	1	K04002.01	CAND	0.549	0.652	0.658	0.86	0
9071593	2	K02257.02	CAND	0.549	0.573	-	-	0
4830605	1	K01660.01	CAND	0.548	-	-	-	0
7841925	2	K01499.02	CAND	0.548	-	-	-	0
9283156	1	K02657.01	CAND	0.547	0.625	-	-	0
11700604	7	-	-	0.547	-	-	-	0
7287118	4	-	-	0.547	-	-	-	0
3967219	3	-	-	0.546	-	-	-	0
9661979	1	K02132.01	CAND	0.546	0.673	-	-	0
12217824	3	-	-	0.546	-	-	-	0
4665571	1	K02393.01	CAND	0.545	-	-	-	0
7102227	3	K01360.03	CAND	0.544	0.708	-	-	0
10397751	4	K02859.04	CAND	0.544	-	-	-	0
10924400	2	-	-	0.544	0.757	-	-	0
12164634	3	-	-	0.544	0.347	-	0.556	1
9086251	1	K02367.01	CAND	0.543	0.547	-	-	0
5450893	1	K02970.01	CAND	0.543	0.7	-	-	0
6268648	3	K01613.03	CAND	0.543	0.585	-	-	1
7582608	4	-	-	0.543	-	-	-	0
8880123	1	K03493.01	CAND	0.541	0.641	-	-	0
7032429	5	-	-	0.54	-	-	-	0
6677841	3	-	-	0.54	0.531	0.829	0.571	0
6300348	1	K00212.01	CAND	0.54	0.899	-	-	0
6707942	2	-	-	0.54	0.682	0.987	-	1
5360082	2	-	-	0.539	0.854	-	-	0
5357545	1	K02219.01	CAND	0.539	-	-	-	0
5544450	1	K03226.01	CAND	0.538	0.675	-	-	0
6632435	2	-	-	0.538	-	-	-	0
11513486	1	K04748.01	CAND	0.538	-	-	-	0
10351231	1	K01166.01	CAND	0.537	0.656	-	-	0
9009953	1	K04014.01	CAND	0.536	-	-	-	0
6441738	1	K01246.01	CAND	0.536	0.67	-	-	0
6889235	2	-	-	0.536	-	-	-	1
8651389	1	K01754.01	CAND	0.536	0.679	0.984	0.948	0
5092266	1	K03045.01	CAND	0.535	0.627	0.521	0.98	0
10922659	1	K03335.01	CAND	0.534	0.719	-	-	0
6775034	5	-	-	0.534	-	-	-	1
8013419	1	K00901.01	CAND	0.534	0.566	-	-	0
8260218	1	K01066.01	CAND	0.533	0.475	-	-	0
7100673	5	K04032.05	CAND	0.532	-	-	-	0
10813078	1	K05831.01	CAND	0.532	0.575	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

9117416	1	K03425.01	CAND	0.532	-	-	-	1
5008245	1	K03770.01	CAND	0.531	-	-	-	0
6268648	4	-	-	0.531	-	-	-	1
4945266	2	-	-	0.531	-	-	-	0
9491205	3	-	-	0.531	-	-	0.385	0
9092504	2	K02716.02	CAND	0.53	-	-	-	0
8874090	2	K01404.02	CAND	0.53	-	-	-	0
7035274	3	-	-	0.53	-	-	-	0
11601584	4	K01831.04	CAND	0.529	-	0.999	0.448	1
7939330	1	K01581.01	CAND	0.527	0.532	-	-	0
4912650	1	K05098.01	CAND	0.526	0.516	0.66	-	0
7363829	1	-	-	0.525	-	0.553	-	0
10345478	2	-	-	0.524	0.632	-	-	1
5724810	1	-	-	0.524	0.526	-	-	0
8935810	1	K01395.01	CAND	0.523	0.808	-	-	0
8707670	5	-	-	0.523	-	-	-	0
4385148	1	K02942.01	CAND	0.521	0.668	-	-	0
9166700	1	K05632.01	CAND	0.521	0.591	-	-	0
8265218	1	K00522.01	CAND	0.52	0.735	-	-	0
6636320	1	K02989.01	CAND	0.52	-	-	-	0
7768451	1	K01527.01	CAND	0.52	0.67	-	-	0
5613821	1	K02915.01	CAND	0.518	0.795	-	-	0
8524712	3	-	-	0.517	-	-	-	0
12069786	3	-	-	0.517	-	-	-	0
6183511	1	K02542.01	CAND	0.516	0.635	-	-	0
9758089	2	K01871.02	CAND	0.516	-	-	-	1
8456679	1	K00102.01	CAND	0.514	-	-	-	0
8702921	3	-	-	0.513	0.405	-	-	1
4840513	2	-	-	0.512	0.946	1.0	0.922	0
8008067	3	K00316.03	CAND	0.512	-	-	-	0
5124667	1	K01822.01	CAND	0.512	0.736	0.722	0.82	0
8240861	3	-	-	0.512	-	-	-	1
8760040	2	K02963.02	CAND	0.512	-	-	-	0
9490506	2	-	-	0.511	-	-	-	0
5372081	7	-	-	0.51	-	-	-	0
12164634	6	-	-	0.509	-	-	-	1
7533425	6	-	-	0.509	-	-	-	0
8758204	1	K02841.01	CAND	0.509	0.547	-	-	0
7869590	2	-	-	0.509	-	-	-	0
7872212	7	-	-	0.507	-	-	-	0
3112129	2	-	-	0.507	-	0.977	0.8	0
9279865	3	-	-	0.507	-	-	-	0
12009347	2	-	-	0.506	0.738	0.999	0.86	0
10187017	6	K00082.06	CAND	0.506	-	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

4939265	3	-	-	0.506	0.659	-	0.462	0
9673338	9	-	-	0.505	-	-	-	0
7117284	2	-	-	0.504	0.44	-	-	0
3122872	1	K03203.01	CAND	0.503	0.769	-	-	0
5963582	1	K02479.01	CAND	0.503	0.668	-	-	0
11046025	1	K01646.01	CAND	0.502	-	-	-	0
11450414	3	K01992.03	FP	0.502	-	-	-	0
11177543	1	K01648.01	CAND	0.501	0.605	-	-	0
4370956	2	-	-	0.501	-	-	-	0
9412462	3	-	-	0.5	-	-	-	1
10853783	2	-	-	0.5	-	-	-	0
11465651	1	K04150.01	CAND	0.499	-	-	-	0
9579208	1	K03165.01	CAND	0.499	-	-	-	0
5792202	4	K00841.04	FP	0.497	0.602	-	-	0
9700145	2	-	-	0.497	-	-	-	0
10798331	1	K02373.01	CAND	0.496	-	-	-	0
4077526	4	K01336.04	CAND	0.496	-	-	-	0
3834322	2	-	-	0.496	0.562	0.525	0.375	1
5004909	1	K03421.01	FP	0.496	0.516	-	-	0
3453026	2	-	-	0.496	-	-	-	0
7115249	7	-	-	0.494	-	-	-	0
8414216	1	K07036.01	FP	0.494	0.766	-	-	0
6606934	2	-	-	0.493	-	0.508	-	1
9086154	1	K04060.01	CAND	0.491	0.481	-	-	0
9588822	2	K04388.02	CAND	0.49	0.672	-	-	1
12257999	1	K02577.01	CAND	0.49	0.539	-	-	0
12316447	3	-	-	0.489	-	-	-	1
8241079	1	K03020.01	CAND	0.488	0.642	-	-	1
7031126	7	-	-	0.487	-	-	-	0
6432345	1	K02757.01	CAND	0.486	0.705	0.999	0.943	0
6115603	10	-	-	0.486	-	-	-	0
10717241	2	K00430.02	CAND	0.486	0.495	-	-	0
5372966	2	-	-	0.485	0.812	0.977	0.99	1
2443393	1	K02603.01	CAND	0.485	-	-	-	0
10482774	7	-	-	0.485	-	-	-	0
6945500	5	-	-	0.484	-	-	-	0
5095635	1	K02607.01	CAND	0.483	0.529	0.995	0.823	0
7031126	3	-	-	0.483	-	-	-	0
10514770	2	-	-	0.481	-	-	0.458	1
2993589	5	-	-	0.481	-	-	-	0
10659313	2	-	-	0.48	-	-	-	1
8690001	7	-	-	0.479	-	-	-	1
8280511	5	K01151.05	CAND	0.479	-	-	-	0
9512981	1	K01466.01	CAND	0.479	-	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

7352016	1	-	-	0.478	-	-	-	0
7047496	2	-	-	0.478	-	-	-	0
8176653	1	K01016.01	FP	0.477	-	-	-	1
7673192	5	K02722.05	CAND	0.477	-	-	-	0
7032218	3	-	-	0.477	-	-	-	0
4566740	8	-	-	0.477	-	-	-	0
4566740	9	-	-	0.476	-	-	-	0
11127641	5	-	-	0.474	-	-	-	0
10332789	2	-	-	0.471	0.726	0.923	-	1
8280511	4	K01151.04	CAND	0.471	-	-	-	0
6756202	3	-	-	0.471	-	-	-	1
3561700	5	-	-	0.471	-	-	-	0
2438502	2	-	-	0.471	0.786	-	0.481	0
3660392	6	-	-	0.471	-	-	-	0
5302881	2	-	-	0.47	-	-	-	0
8702921	2	-	-	0.47	-	-	-	1
7211759	8	-	-	0.468	-	-	-	0
10028792	3	K01574.03	CAND	0.466	-	-	-	0
5476864	2	-	-	0.464	0.529	-	-	0
6140084	10	-	-	0.464	-	-	-	0
7117444	6	-	-	0.464	-	-	-	0
10152836	2	-	-	0.463	0.555	0.535	-	1
8826317	10	-	-	0.462	-	-	-	0
10206675	2	-	-	0.462	-	-	-	0
4263801	4	-	-	0.462	-	-	-	0
9099950	7	-	-	0.462	-	-	-	0
11100532	9	-	-	0.461	-	-	-	0
8242681	2	-	-	0.461	-	-	0.455	1
8527297	3	-	-	0.461	-	-	-	0
9032900	4	-	-	0.459	0.446	-	-	1
1433399	3	-	-	0.458	-	-	-	0
9237305	5	-	-	0.458	-	-	-	0
7041634	2	-	-	0.458	0.514	-	-	0
3450040	1	K04205.01	CAND	0.458	0.775	-	-	0
10397751	5	K02859.05	CAND	0.458	-	-	-	0
3975085	7	-	-	0.458	-	-	-	0
10132618	2	-	-	0.455	-	-	-	0
8971294	2	-	-	0.455	-	-	-	0
7335514	1	K06860.01	CAND	0.455	-	-	-	0
3862246	2	-	-	0.455	0.565	-	0.429	1
5787972	10	-	-	0.454	-	-	-	0
10877367	6	-	-	0.454	-	-	-	0
5088084	4	-	-	0.454	-	-	-	0
10552700	4	-	-	0.452	-	-	-	0

Continued on next page

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

9457728	1	K04637.01	CAND	0.449	0.646	-	0.429	0
2712825	1	K08086.01	FP	0.449	-	-	-	0
6783562	8	-	-	0.446	-	-	-	0
9642018	2	-	-	0.445	-	-	-	1
3120650	4	-	-	0.445	-	-	-	0
8950019	8	-	-	0.444	-	-	-	0
7880676	2	-	-	0.442	0.473	-	-	0
9278696	3	-	-	0.441	-	-	-	0
8783270	5	-	-	0.44	-	-	-	0
2436450	6	-	-	0.439	-	-	-	0
8553462	10	-	-	0.439	-	-	-	0
8431611	3	-	-	0.438	-	-	-	0
4739229	3	-	-	0.436	-	-	-	0
8176564	1	K02720.01	CAND	0.435	-	-	-	0
6945362	8	-	-	0.434	-	-	-	0
9178894	3	-	-	0.433	-	-	-	0
1026133	2	-	-	0.433	-	-	-	0
12644769	2	-	-	0.432	-	-	-	1
6041680	3	-	-	0.43	-	-	-	0
9156461	10	-	-	0.43	-	-	-	0
7533425	5	-	-	0.43	-	-	-	0
8894646	1	K02641.01	CAND	0.429	0.485	-	-	0
10843431	2	K07378.02	CAND	0.428	-	-	-	0
9006186	4	K02169.04	CAND	0.424	-	-	-	0
9149789	2	-	-	0.423	-	0.393	-	1
8096395	1	K07587.01	CAND	0.423	-	-	-	0
6387450	2	-	-	0.423	0.43	-	-	1
10652379	10	-	-	0.423	-	-	-	0
3764879	1	K02141.01	FP	0.423	-	-	-	0
7767559	1	K00895.01	FP	0.422	-	-	-	1
11356602	1	K07439.01	FP	0.42	-	-	-	0
4347340	4	-	-	0.42	-	-	-	0
10395312	10	-	-	0.413	-	-	-	0
3247616	4	-	-	0.413	-	-	-	0
8631160	1	K01271.01	CAND	0.411	-	-	-	1
11968463	6	-	-	0.411	-	-	-	0
7446357	10	-	-	0.41	-	-	-	0
2436450	7	-	-	0.409	-	-	-	0
8328003	6	-	-	0.408	0.41	-	-	0
5812648	4	-	-	0.408	-	-	-	0
8840117	8	-	-	0.408	-	-	-	0
6762829	5	-	-	0.406	0.409	0.893	0.5	1
7446357	8	-	-	0.402	-	-	-	0
6721523	7	-	-	0.401	-	-	-	0

Continued on next page

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

6500206	1	K02451.01	FP	0.401	0.418	-	-	0
8362880	2	-	-	0.399	-	-	-	0
7900137	2	-	-	0.398	-	-	-	0
5471059	1	K03956.01	FP	0.397	-	-	-	0
7816992	10	-	-	0.395	-	-	-	0
5265699	9	-	-	0.394	-	-	-	0
9574614	1	K01745.01	FP	0.391	-	-	-	1
1718958	1	K04053.01	CAND	0.391	0.411	-	-	0
9084778	1	K01631.01	FP	0.39	-	-	-	1
5295670	4	-	-	0.387	-	-	-	0
6277594	2	-	-	0.386	-	-	-	0
8396405	1	K01733.01	CAND	0.383	0.517	-	-	0
4157325	4	K01860.04	FP	0.382	0.592	-	-	0
8613535	4	-	-	0.381	-	-	-	0
9166826	7	-	-	0.381	-	-	-	0
11919968	9	-	-	0.379	-	-	-	0
8818497	2	-	-	0.373	-	-	-	0
8703129	1	K02758.01	CAND	0.37	-	-	-	1
3558849	1	K04307.01	CAND	0.364	-	-	-	0
4066898	3	-	-	0.362	-	-	-	0
10801647	8	-	-	0.356	-	-	-	0
10321305	8	-	-	0.354	-	-	-	0
7115878	5	-	-	0.353	-	-	-	0
5652983	1	K00371.01	FP	0.352	-	-	-	1
10031808	6	-	-	0.351	-	-	-	1
8460081	5	-	-	0.35	-	-	-	0
4145040	4	-	-	0.347	-	-	-	0
7582608	6	-	-	0.345	-	-	-	0
4735826	2	-	-	-	0.981	-	-	0
8953059	2	-	-	-	0.922	0.999	0.879	1
8822421	1	K06188.01	FP	-	0.888	-	-	0
7097965	1	K02083.01	CAND	-	0.881	-	-	0
11251058	1	K07429.01	FP	-	0.847	-	-	0
9896435	2	-	-	-	0.84	-	-	1
8142942	1	K01985.01	CAND	-	0.83	-	-	0
12647577	1	K04530.01	CAND	-	0.827	-	-	0
3097352	2	-	-	-	0.813	0.513	-	1
9427402	1	K01397.01	CAND	-	0.812	-	-	0
1026957	1	K00958.01	CAND	-	0.808	0.788	0.866	1
11656302	2	-	-	-	0.803	-	-	1
8742590	1	K01281.01	CAND	-	0.792	-	-	0
4458082	2	K02303.02	CAND	-	0.791	-	-	0
10015937	1	K01720.01	CAND	-	0.777	-	-	0
7051180	1	K00064.01	CAND	-	0.771	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

11904734	1	K01764.01	CAND	-	0.768	-	-	0
7779077	1	K01842.01	CAND	-	0.767	-	-	0
10354039	1	K01159.01	CAND	-	0.763	-	-	0
10917681	1	K01963.01	CAND	-	0.763	-	-	0
3648437	1	K01861.01	CAND	-	0.756	-	-	0
10094670	1	K01984.01	CAND	-	0.748	-	-	0
8256453	1	K02573.01	CAND	-	0.747	-	-	0
6291837	1	K00308.01	CAND	-	0.746	-	-	0
5003117	2	-	-	-	0.742	-	0.556	1
10843431	1	K07378.01	CAND	-	0.741	0.961	-	0
8949925	1	K02972.01	CAND	-	0.733	-	-	0
7103919	1	K04310.01	CAND	-	0.732	-	-	0
3967326	1	K02084.01	CAND	-	0.729	-	-	0
9528420	2	-	-	-	0.721	0.995	0.657	1
7017274	2	K03209.02	CAND	-	0.718	-	-	0
10736489	1	K07368.01	CAND	-	0.717	-	-	0
12017140	2	-	-	-	0.702	0.512	-	1
7021681	2	K00255.02	CAND	-	0.701	-	-	0
8581240	1	K03111.01	CAND	-	0.699	-	-	0
4665571	2	K02393.02	CAND	-	0.699	0.681	0.821	0
9758089	1	K01871.01	CAND	-	0.696	-	-	1
6185476	1	-	-	-	0.69	-	-	0
5816165	1	K01043.01	FP	-	0.688	0.436	0.471	0
3756264	1	K03108.01	CAND	-	0.687	-	-	0
12456063	1	K04329.01	CAND	-	0.685	-	-	0
8605074	2	-	-	-	0.683	0.902	-	1
8230809	2	-	-	-	0.682	-	-	1
8591693	1	K02123.01	CAND	-	0.679	-	-	0
7750419	1	K01708.01	CAND	-	0.679	-	-	0
6707908	1	K02014.01	CAND	-	0.678	-	-	0
8158429	1	K05482.01	CAND	-	0.677	-	-	0
9602613	1	K02612.01	CAND	-	0.675	-	-	0
9635606	1	K02535.01	CAND	-	0.67	-	-	0
9715925	2	-	-	-	0.669	-	-	1
4912991	2	-	-	-	0.669	-	0.423	1
4069213	2	-	-	-	0.664	0.687	-	1
8845026	2	-	-	-	0.663	-	-	1
9834731	1	K03043.01	CAND	-	0.661	-	-	0
2719873	2	-	-	-	0.651	-	-	1
5705819	1	K02091.01	CAND	-	0.649	-	-	0
8617363	1	K02945.01	CAND	-	0.648	-	-	0
9886224	2	-	-	-	0.641	0.988	-	1
3554031	2	K01194.02	FP	-	0.635	-	-	0
10155029	1	K03208.01	CAND	-	0.632	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

11013201	2	K00972.02	FP	-	0.631	-	-	1
5475042	1	K03050.01	CAND	-	0.63	-	-	0
11856178	1	K06246.01	CAND	-	0.629	-	-	0
7605600	2	-	-	-	0.629	0.997	-	1
4676964	1	K03069.01	CAND	-	0.627	-	-	0
9472074	1	K02735.01	CAND	-	0.625	-	-	0
3545135	1	K02755.01	CAND	-	0.62	-	-	0
5003670	1	K04524.01	CAND	-	0.619	-	-	0
4919550	1	K04766.01	CAND	-	0.617	-	-	0
8824737	1	K03347.01	CAND	-	0.615	-	-	0
5098444	2	-	-	-	0.615	-	-	1
2975770	2	K01788.02	FP	-	0.614	-	-	0
8022489	1	K02674.01	CAND	-	0.614	-	-	1
5308537	1	K04409.01	CAND	-	0.608	-	-	0
1724719	2	K04212.02	CAND	-	0.606	-	-	0
6523351	1	K03117.01	CAND	-	0.606	-	-	0
12208631	1	K02449.01	CAND	-	0.602	-	-	0
4150390	2	-	-	-	0.596	-	-	1
9011877	1	K05597.01	CAND	-	0.595	-	-	0
12602314	1	K02853.01	CAND	-	0.595	-	-	0
7609674	1	K03128.01	CAND	-	0.594	-	-	0
5979863	2	-	-	-	0.593	-	0.667	1
11124436	1	K04442.01	CAND	-	0.586	-	-	0
5270698	2	-	-	-	0.578	0.999	-	0
7106173	1	K03083.01	CAND	-	0.575	-	-	0
9411317	2	-	-	-	0.574	-	-	1
7446631	1	K02598.01	CAND	-	0.572	-	-	0
5003670	2	K04524.02	CAND	-	0.569	-	-	0
10514430	4	-	-	-	0.568	-	-	0
11200405	2	-	-	-	0.567	-	-	1
4857058	1	K03061.01	CAND	-	0.565	-	-	0
11081504	1	K04287.01	CAND	-	0.565	-	-	0
2973386	1	K03034.01	CAND	-	0.565	-	-	0
5211199	2	K02158.02	CAND	-	0.563	-	-	0
9957627	1	K00592.01	CAND	-	0.563	-	-	0
10141900	2	K01082.02	CAND	-	0.558	-	-	0
10597693	1	K02958.01	CAND	-	0.555	-	-	0
7918478	1	K04209.01	CAND	-	0.553	-	-	0
3559860	1	K03440.01	FP	-	0.551	-	-	0
9836563	1	K04421.01	CAND	-	0.551	-	-	0
9020114	1	K03088.01	CAND	-	0.549	-	-	0
5428657	1	K06130.01	CAND	-	0.549	-	-	0
10874215	1	K02305.01	CAND	-	0.548	-	-	0
10265898	2	K00732.02	CAND	-	0.546	-	-	0

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Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

8827575	1	K03052.01	CAND	-	0.544	-	-	0
11125797	1	K03371.01	CAND	-	0.543	-	-	0
7512982	2	K01480.02	CAND	-	0.543	-	-	0
6131236	1	K01051.01	CAND	-	0.542	-	-	0
8804283	2	K01276.02	CAND	-	0.537	-	-	0
4172805	1	K04427.01	CAND	-	0.536	-	-	0
5106313	1	K02878.01	CAND	-	0.536	-	-	0
12061969	1	K02061.01	FP	-	0.536	-	-	0
8390826	1	-	-	-	0.535	-	-	0
6041734	2	-	-	-	0.534	0.919	0.87	1
5450814	2	-	-	-	0.531	-	-	1
4860678	2	K01602.02	CAND	-	0.53	-	-	0
9552608	2	-	-	-	0.527	-	0.458	1
7107802	2	K02420.02	CAND	-	0.527	-	-	0
9002538	1	K03196.01	CAND	-	0.527	-	-	0
5897826	3	-	-	-	0.527	-	-	1
5544450	2	K03226.02	CAND	-	0.526	-	-	0
6945786	1	K03136.01	CAND	-	0.526	-	-	0
9716028	1	K04273.01	CAND	-	0.525	-	-	0
6061773	1	K02001.01	CAND	-	0.525	-	-	0
2574338	1	K01030.01	CAND	-	0.525	0.765	0.949	0
9474222	2	-	-	-	0.524	0.998	-	1
11599038	2	K01437.02	FP	-	0.521	-	-	0
8624520	1	K01816.01	CAND	-	0.521	-	-	1
5103942	2	-	-	-	0.521	-	-	0
2019477	1	K06093.01	FP	-	0.52	-	-	0
4061149	1	K01201.01	CAND	-	0.52	-	-	0
5436338	1	K02835.01	CAND	-	0.519	-	-	0
4060229	1	K04570.01	CAND	-	0.515	-	-	0
9288237	1	K03114.01	CAND	-	0.514	-	-	0
9896018	3	K02579.03	CAND	-	0.513	-	-	0
6026737	1	K02949.01	CAND	-	0.511	-	-	0
11246161	2	-	-	-	0.51	0.878	0.5	0
6593150	1	K03037.01	CAND	-	0.51	0.51	-	0
11465950	1	K02620.01	CAND	-	0.509	0.834	0.959	0
6153407	1	K03179.01	CAND	-	0.508	-	-	0
8838950	1	K02421.01	CAND	-	0.507	-	-	0
11869052	1	K00120.01	CAND	-	0.506	-	-	1
8963721	1	K02233.01	FP	-	0.506	-	-	0
5351250	5	K00408.05	FP	-	0.503	-	-	0
5542466	2	K01590.02	CAND	-	0.502	-	-	0
11517719	2	-	-	-	0.501	-	-	1
9650989	1	K03095.01	CAND	-	0.501	-	-	0
2986833	1	K04875.01	CAND	-	0.501	-	-	0

Continued on next page

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

10666592	2	-	-	-	0.498	-	-	0
4547603	1	K02855.01	CAND	-	0.497	-	-	0
5906426	1	K02377.01	CAND	-	0.496	-	-	0
7288444	1	K03482.01	CAND	-	0.496	-	-	0
7377033	1	K00882.01	FP	-	0.494	-	-	1
7450747	1	K04267.01	CAND	-	0.494	0.883	-	0
6792908	1	K04341.01	CAND	-	0.494	-	-	0
6268648	2	K01613.02	CAND	-	0.494	-	-	1
1849702	1	K02538.01	CAND	-	0.493	-	-	0
8409588	1	K00690.01	FP	-	0.49	-	-	1
9032900	2	-	-	-	0.481	-	-	1
4770365	3	K01475.03	CAND	-	0.48	-	-	0
12301181	2	K02059.02	CAND	-	0.476	-	-	1
2852941	1	K04298.01	CAND	-	0.476	-	-	0
7222086	1	K01701.01	CAND	-	0.469	-	-	0
12164634	2	-	-	-	0.466	-	-	1
11246161	1	K02796.01	CAND	-	0.465	-	-	0
3448132	2	-	-	-	0.462	-	-	0
4739229	2	-	-	-	0.456	-	-	0
8313667	1	K01145.01	CAND	-	0.455	-	-	0
5551672	1	K03119.01	CAND	-	0.452	0.829	-	0
11509792	1	-	-	-	0.436	-	-	0
3338885	2	K01845.02	CAND	-	0.434	-	-	0
3437940	2	-	-	-	0.424	-	-	0
10863286	2	-	-	-	0.423	-	-	1
5446285	3	-	-	-	0.418	0.7	-	0
12302530	3	-	-	-	0.416	-	0.404	0
10018866	2	-	-	-	0.41	-	-	0
8264404	2	-	-	-	0.406	-	-	0
2984632	2	-	-	-	0.405	-	-	0
5689351	6	-	-	-	0.375	-	-	0
8631751	1	K02453.01	CAND	-	0.373	-	-	0
9897838	1	-	-	-	0.372	-	-	0
5384713	5	-	-	-	0.368	-	-	1
4769931	1	K04058.01	FP	-	0.36	-	-	0
6603756	2	-	-	-	-	1.0	-	1
7972785	2	-	-	-	-	0.999	0.969	1
6756669	2	-	-	-	-	0.996	0.924	1
8416523	2	-	-	-	-	0.995	-	0
5774557	2	-	-	-	-	0.995	-	0
8953257	2	-	-	-	-	0.993	0.841	1
8561063	4	-	-	-	-	0.99	-	0
9705459	2	-	-	-	-	0.985	0.839	1
8236479	1	-	-	-	-	0.978	-	0

Continued on next page

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

3558981	2	-	-	-	-	0.976	-	1
4049124	2	-	-	-	-	0.976	-	1
9098590	2	-	-	-	-	0.959	-	1
5608566	2	-	-	-	-	0.947	-	1
6500206	2	-	-	-	-	0.939	-	0
12644769	3	-	-	-	-	0.911	-	1
6451605	1	-	-	-	-	0.906	-	0
8415004	4	-	-	-	-	0.876	-	0
6504534	3	-	-	-	-	0.824	-	1
5446285	2	-	-	-	-	0.823	-	0
3323887	4	-	-	-	-	0.817	-	0
6750902	2	-	-	-	-	0.798	-	0
6185476	3	-	-	-	-	0.781	-	0
7270230	2	-	-	-	-	0.773	-	1
7269881	2	-	-	-	-	0.757	-	0
6185476	2	-	-	-	-	0.757	-	0
12010534	2	-	-	-	-	0.749	-	1
7119481	3	K00566.03	CAND	-	-	0.736	-	0
10073672	1	K02764.01	CAND	-	-	0.732	-	0
5728283	2	-	-	-	-	0.726	-	1
9719636	2	-	-	-	-	0.715	-	1
5114623	8	-	-	-	-	0.708	-	0
6060277	2	-	-	-	-	0.683	-	0
10419211	2	-	-	-	-	0.678	-	1
4932348	2	-	-	-	-	0.655	-	1
9413313	1	-	-	-	-	0.637	-	0
6149910	1	K02469.01	CAND	-	-	0.613	-	0
3634755	2	-	-	-	-	0.606	-	0
5810113	2	-	-	-	-	0.596	-	0
11285136	2	-	-	-	-	0.584	-	1
3547091	2	-	-	-	-	0.575	-	1
10657664	2	-	-	-	-	0.561	-	1
8329629	2	-	-	-	-	0.559	-	0
9202151	1	K01393.01	CAND	-	-	0.55	-	0
8292150	2	-	-	-	-	0.537	-	0
10527135	2	-	-	-	-	0.536	-	0
2720354	2	-	-	-	-	0.533	-	1
6462874	2	K01231.02	FP	-	-	0.522	-	0
11391018	2	-	-	-	-	0.5	-	0
9791509	3	-	-	-	-	0.474	-	0
11252617	2	K06236.02	FP	-	-	0.466	-	1
3342467	2	-	-	-	-	0.458	-	0
6209347	5	-	-	-	-	0.414	-	1
7186665	2	-	-	-	-	-	0.75	1

Continued on next page

Table 12: Confirmed planets ordered by LR. Eclipsing Binaries (eb=1)

4773392	1	K04367.01	CAND	-	-	-	0.538	0
6762829	4	-	-	-	-	-	0.514	1
7186665	1	K03033.01	FP	-	-	-	0.5	1
5014753	2	-	-	-	-	-	0.5	1
3851949	2	-	-	-	-	-	0.458	1
5357470	2	-	-	-	-	-	0.455	0
3962728	2	-	-	-	-	-	0.452	0
7051984	2	-	-	-	-	-	0.452	1
8695779	2	-	-	-	-	-	0.444	1
6866228	2	-	-	-	-	-	0.444	1
5982353	2	-	-	-	-	-	0.429	1
8038679	1	-	-	-	-	-	0.424	0
6609270	2	K03090.02	FP	-	-	-	0.409	0
9710998	1	-	-	-	-	-	0.406	0
7299905	1	-	-	-	-	-	0.4	0
8681125	1	-	-	-	-	-	0.393	0
6785967	1	-	-	-	-	-	0.379	0
10068030	2	-	-	-	-	-	0.375	1
11249624	3	-	-	-	-	-	0.375	1
10024862	2	-	-	-	-	-	0.375	0
2452440	2	-	-	-	-	-	0.366	1
2163457	1	-	-	-	-	-	0.36	0
12207117	2	-	-	-	-	-	0.359	0
5990753	2	-	-	-	-	-	0.35	1

9.4 Extract of recovered planets ordered by Random Forest (RF_vif) with eclipsing binaries

Table 13 shows the full list of planets. This is an extract of Table 12 but ordered by Random Forest results. Many TCE cases are returned with high probability but they are in systems with eclipsing binaries (eb=1) which may explain why they were not included in the KOI table.

Table 13: Confirmed planets ordered by RF_vif Eclipsing Binaries (eb=1)

kepid	**plnt num**	**kname**	**dispos**	**RF_vif**	**GB_vif**	**LR**	**DT**	*eb*
9838975	2	-	-	0.99	1.0	0.927	0.879	1
3734868	2	-	-	0.99	1.0	0.778	0.643	1
5372966	2	-	-	0.99	0.977	0.485	0.812	1
8552719	2	K01792.02	FP	0.98	1.0	0.949	0.888	1
5092266	1	K03045.01	CAND	0.98	0.521	0.535	0.627	0
5376836	2	-	-	0.98	0.999	0.819	0.869	1
7037540	2	-	-	0.98	0.999	0.956	0.889	1
8180020	2	-	-	0.979	0.999	0.927	0.925	1
9446824	2	-	-	0.979	0.999	0.908	0.913	1
1571511	2	-	-	0.979	0.999	0.614	0.666	1
9411166	2	-	-	0.979	0.974	0.921	0.684	0
8892910	2	-	-	0.978	0.998	0.809	0.591	1
8176650	2	-	-	0.971	1.0	0.905	0.874	0
5370302	2	-	-	0.971	1.0	0.866	0.908	1
3970233	2	-	-	0.97	0.999	0.935	0.972	1
4814502	1	K04004.01	CAND	0.969	1.0	0.653	0.869	0
12504988	2	-	-	0.969	1.0	0.905	0.921	1
7972785	2	-	-	0.969	0.999	-	-	1
5980783	1	K02967.01	CAND	0.968	0.854	0.663	0.662	0
5031857	2	K01573.02	CAND	0.967	-	0.879	0.584	0
6762829	2	-	-	0.96	0.999	0.892	0.839	1
10016874	1	K00426.01	CAND	0.96	0.717	0.85	0.809	0
10904857	2	-	-	0.96	0.994	0.845	0.879	1
7584650	1	K02631.01	CAND	0.96	1.0	0.805	0.885	0
7975727	2	-	-	0.96	0.999	0.804	0.852	1
10616571	3	-	-	0.96	1.0	0.731	0.724	1
11465950	1	K02620.01	CAND	0.959	0.834	-	0.509	0
5978559	1	K02321.01	CAND	0.959	0.992	0.693	0.698	0
10794087	1	K01316.01	CAND	0.959	1.0	0.914	0.899	0
3097926	1	K02186.01	CAND	0.959	0.985	0.837	0.804	0
7023960	2	-	-	0.957	0.996	0.798	0.859	1
9995771	1	K03470.01	CAND	0.957	1.0	0.636	0.821	0
2581316	2	**K03681.02**	CAND	0.952	1.0	0.942	0.932	0
3342592	2	-	-	0.949	0.998	0.904	0.935	1
5786676	1	K00650.01	CAND	0.949	0.999	0.858	0.811	0

9.5 Comparison of predictions from Shallue and Vanderburg (2018) to LR/DT predictions

The last machine learning paper on kepler data Shallue and Vanderburg (2018) published a table (4) captioned "Summary of new Kepler TCEs predicted to be planets by our model with probability greater than 0.8.". Table 14 compares these results against the results obtained in section 9.3.
Shallue and Vanderburg (2018) declared the first and fourth models to be confirmed exoplanets 11442793,4852528 and the model 8480285 a strong candidate.
Six of the top nine [9] results recovered by Shallue and Vanderburg (2018) have also been recovered by our model and the results are roughly comparable which reinforces the confidence in the predictions made here. However the model in this paper has more predictions as it looked at a much larger number of systems.
There was not time (or space in technical report) to examine each planet individually but this was foreseen as future work.

Table 14: Comparison of 'new' TCE's predicted by Shallue vs TCE's predicted by LR and DT

Kepid	**Prediction Shallue and Vanderburg (2018)**	**Prediction (LR)**	**Prediction (DT)**	**koi_disp**
11442793	0.942	None	None	-
8480285	0.941	0.971	0.948	CAND
11568987	0.92	0.805	0.741	CAND
4852528	0.916	None	None	-
5972334	0.896	0.915	0.933	CAND
10337517	0.86	0.697	0.88	CAND
11030475	0.858	0.907	0.875	CAND
4548011	0.852	0.575	0.601	CAND
3832474	0.847	None	None	-

[9] The missing three cases may be due to the lower S/N noise threshold used by Shallue and Vanderburg (2018)

10 Helper Programs

The programs Treat4.py and Treat5.py are used to present results and rely on several helper classes shown below.

- csv2tex.py shown in Figure 29 converts a csv file to a latex table and can be imported as a class or called independently.
- rpt2tex.py shown in Figure 30 creates a latex report using files produced by matplotlib.
- myfit.py shown in Figure 31 fits the or overfits the models and saves to a pickle file.

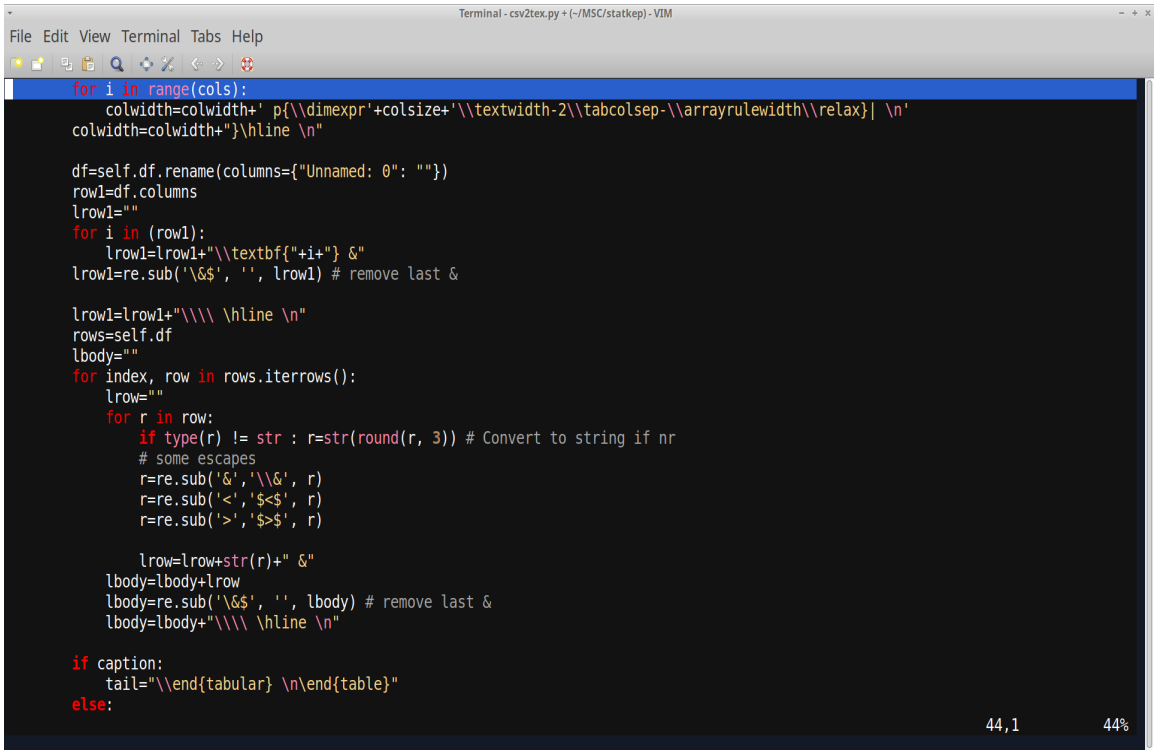


Figure 29: csv2tex.py: Converts a csv file to a latex table and can be imported as a class or called independently

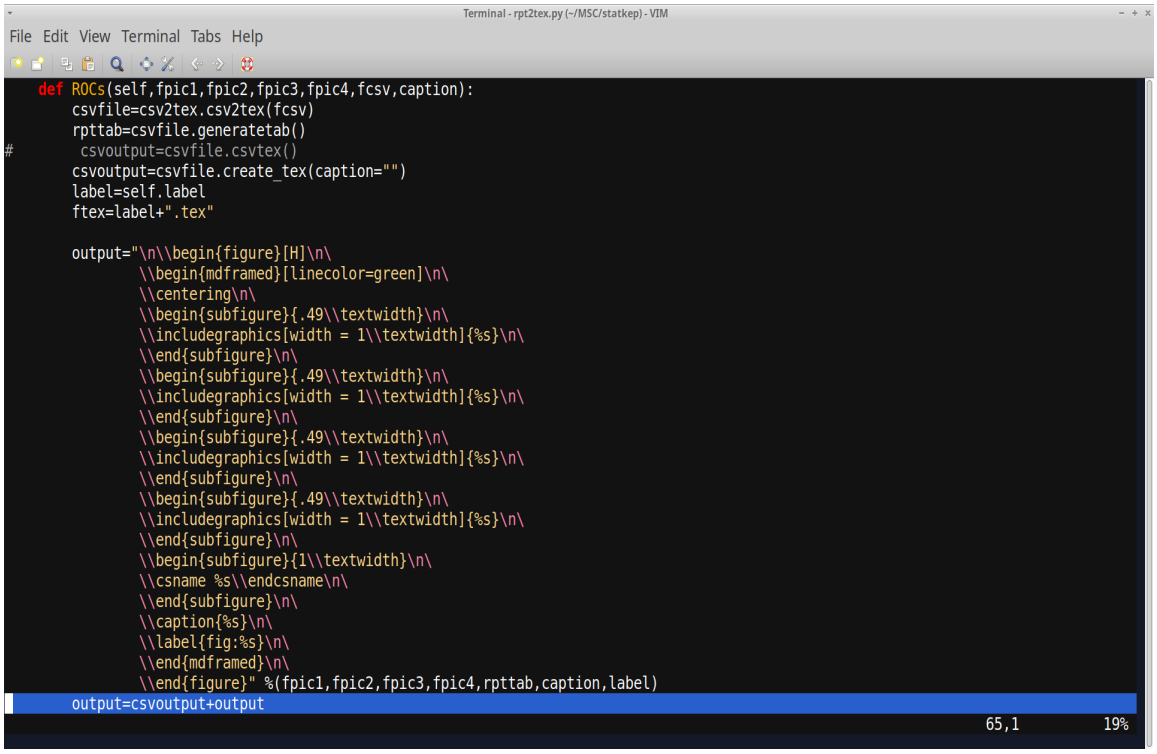


Figure 30: rpt2tex.py: Creates a latex file using files produced by matplotlib see Figure 19

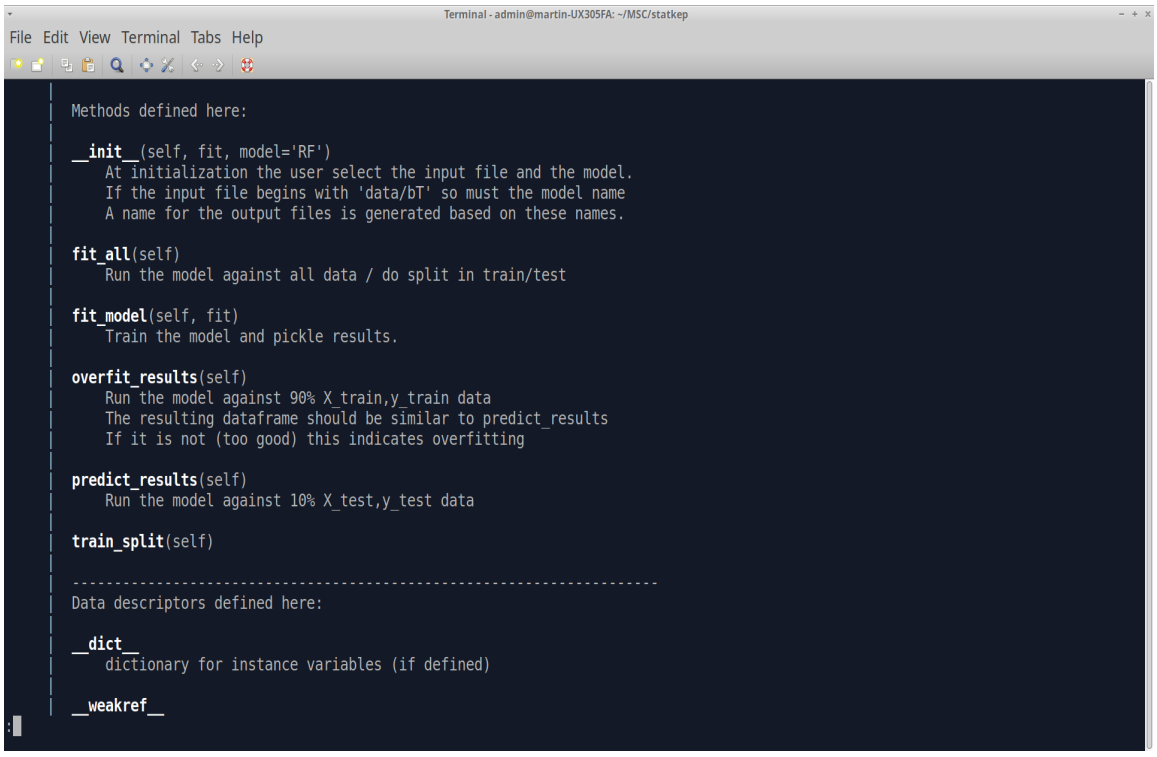


Figure 31: myfit.py: Generates models and save in pickle

11 Conclusion

This manual contains data which could not be included in the original report due to lack of space, including results. The appendix shows original R code which was not used and a description of the DV used for training (koi_disposition).

12 Appendix

12.1 Initial comparisons using R caret

Initially evaluation was performed using the R caret package. Naïve Bayes and Random Forest were compared.The code was developed in rstudio as shown in Figure 32. R proved to be less consistent than python and was abandoned by it was useful for initial insights and is included for completeness.

12.1.1 Naive Bayes

Naïve Bayes is not ideal for datasets with many numeric features Lantz (2019).

12.1.2 Random Forest

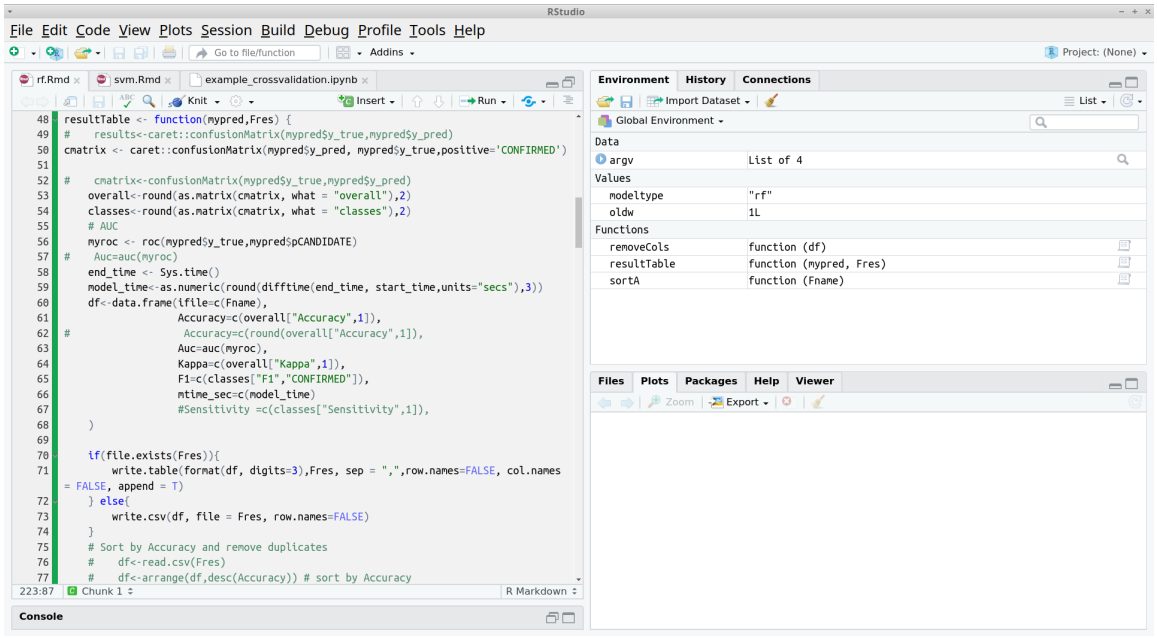
The R package caret was tuned for the optimum values of mtry and ntree using uncleaned data 5. An accuracy of 0.913 was achieved using 1000 ntree and 6 retries see Table 15

Table 15: Initial Random Forest results after merging of TCE and KOI tables

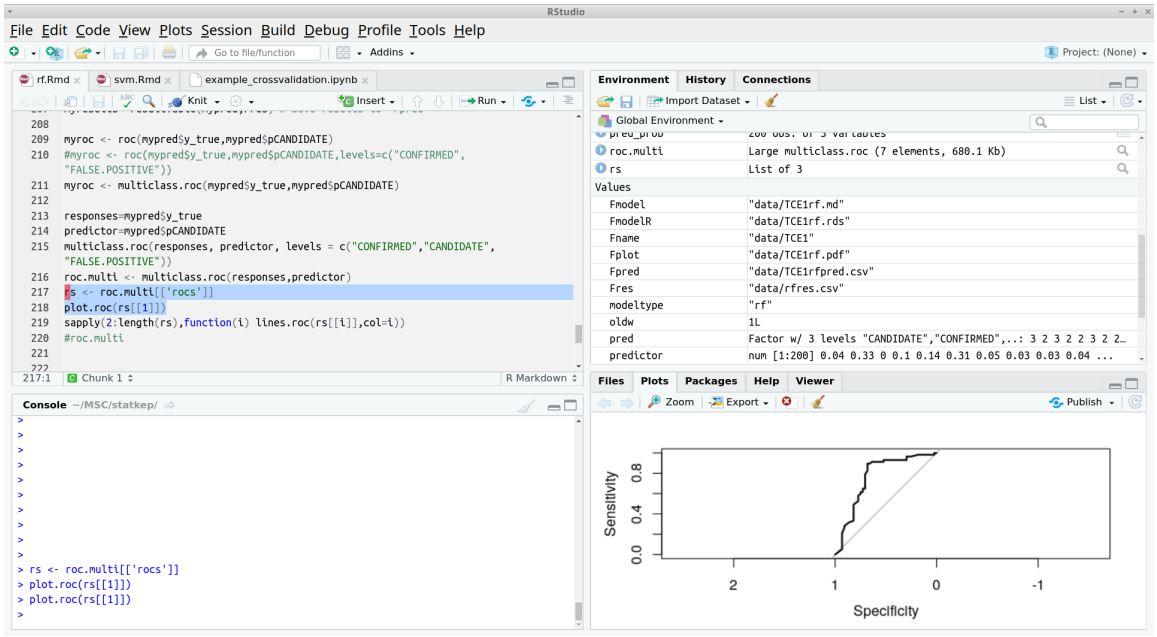
RF_trainer	**ntree**	**mtry**	**Accuracy**
data/0_0.3TCE2_RF_500_6.rds	500	6	0.911354581673307
data/0_0.3TCE2_RF_500_8.rds	800	8	0.909860557768924
data/0_0.3TCE2_RF_800_10.rds	800	10	0.911354581673307
data/0_0.3TCE2_RF_1000_6.rds	1000	6	**0.913346613545817**
data/0_0.3TCE2_RF_1000_8.rds	1000	8	0.911852589641434
data/0_0.3TCE2_RF_1000_10.rds	1000	10	0.909860557768924

12.1.3 Results of comparison between Naïve Bayes and Random Forest

Random Forest section 12.1.2 achieved an accuracy of 0.913 without data cleaning.Removing noise affected these results little as it did with python sklearn.
Naïve Bayes achieved an accuracy of 0.785 using uncleaned data. Multivariate noise was then reduced using Mahlanobis calculations with ibm-spss and Naïve Bayes accuracy increased to 0.832.
These results indicate tree methods such as random forest are robust to noise and produce better results while requiring less data cleaning.

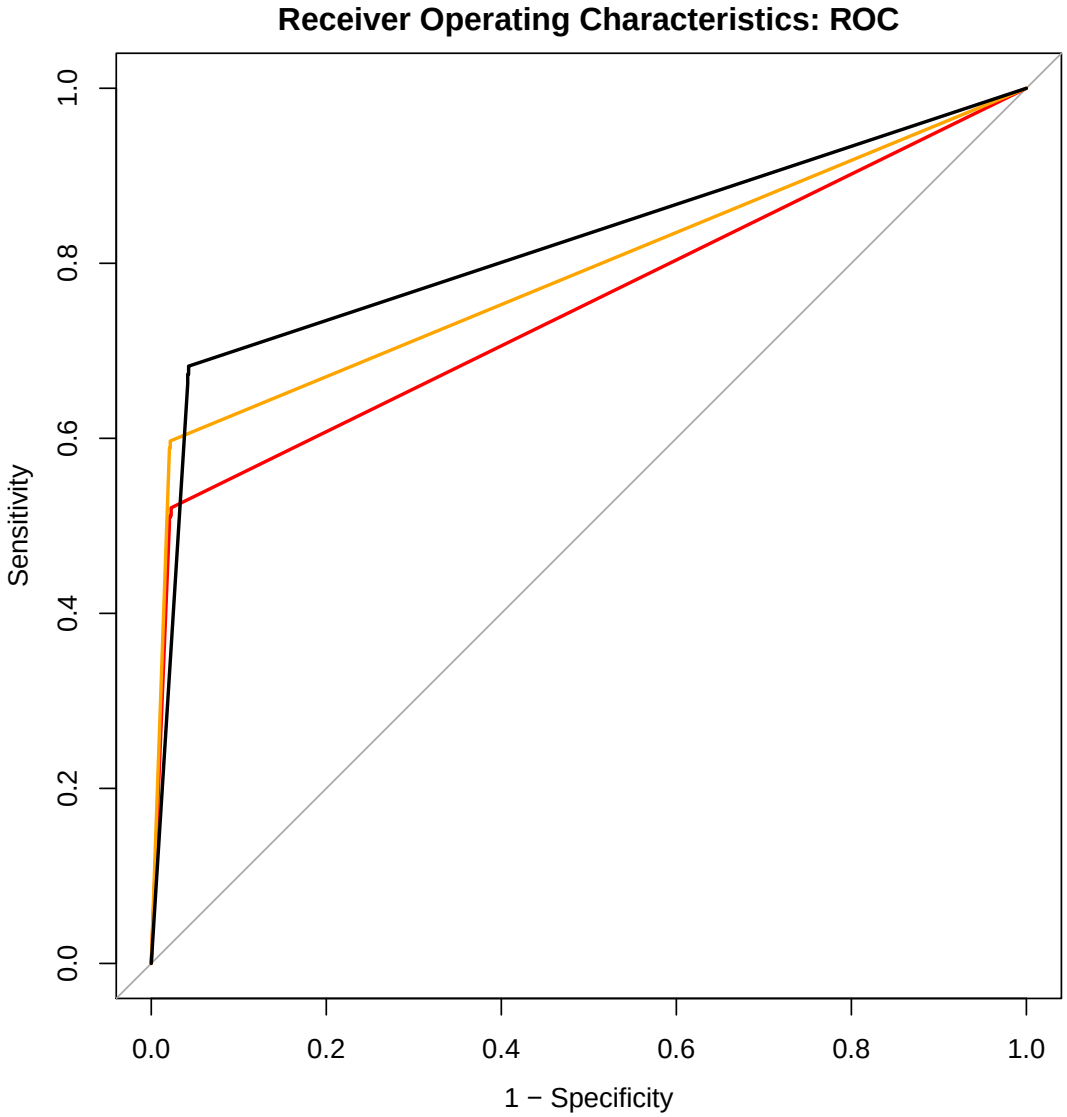


(a) R code to generate RF results



(b) R code to create a simple ROC curve

Figure 32: R code on R studio to implement Random Forest



File Name	Accuracy	Kappa	Fmeasure	AUC	Note
TKmahl.csv	0.832	0.648	0.866	0.82	Outliers removed
TK.csv	0.785	0.708	0.821	0.788	Default
TKe.csv	0.747	0.671	0.796	0.749	Before calculating _sn 3

Figure 33: Exploratory Results: Initial comparison using Naïve Bayes
TCE1mah1.csv -after removing outliers using Mahlanobis distance
TCE1e.csv-before changing _err to _sn (signal to noise)

12.2 Data Description of DV (koi_disposition) and IVs

Table 16 shows the detailed description of the single DV from NASA [4] [5]. An explanation of all IV's before modification are on the NASA website [2], [3]

Table 16: Detailed description of the DV koi_dispostion

Name	**Description** Kepler Object of Interest (TCE)	**Details** [5]
koi_disposition	Exoplanet Archive Disposition	The category of this KOI from the Exoplanet Archive. Current values are CANDIDATE, FALSE POSITIVE, NOT DISPOSITIONED or CONFIRMED. All KOIs marked as CONFIRMED are also listed in the Exoplanet Archive Confirmed Planet table. Designations of CANDIDATE, FALSE POSITIVE, and NOT DISPOSITIONED are taken from the Disposition Using Kepler Data.

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