Horse Survival Prediction

Ankahor - Saransh Kumar

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[1]
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```
%%capture
%%time
%%bash
rm -r /kaggle/working/.kaggle
mkdir -p ~/.kaggle
echo '{"username":"saranshkumar","key":"b0ed8c7e1a7ac4a"}' > ~/.kaggle/kaggle.json
chmod 600 ~/.kaggle/kaggle.json
```

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[2]
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```
%%capture
%%time
%%bash
kaggle competitions download -c horse-survival-prediction
unzip -q horse-survival-prediction.zip -d /kaggle/working/data
find /kaggle/working/data -type f -name "*.csv" | head -20
```

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[3]
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```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
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[4]
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[5]
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[6]
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[7]
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[8]
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[11]
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[12]
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[13]
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[14]
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[15]
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[16]
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[17]
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[19]
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[22]
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[23]
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[24]
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[25]
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[26]
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[27]
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[28]
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[31]
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[36]
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[42]
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[43]
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[48]
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[49]
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[50]
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[51]
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[52]
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[54]
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[55]
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[56]
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[58]
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[59]
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[60]
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[61]
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[62]
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[63]
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[68]
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[69]
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[71]
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[72]
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[73]
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[74]
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[75]
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[76]
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[77]
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[78]
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[79]
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[80]
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[81]
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[82]
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[83]
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[84]
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[85]
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[86]
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[87]
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[88]
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[89]
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pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[90]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[91]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[92]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[93]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[94]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[95]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[96]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[97]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[98]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[99]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[100]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[101]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[102]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[103]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[104]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[105]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[106]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[107]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[108]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[109]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[110]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[111]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[112]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[113]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[114]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[115]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[116]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[117]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[118]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[119]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[120]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[121]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[122]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[123]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[124]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[125]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[126]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[127]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[128]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[129]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[130]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[131]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[132]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[133]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[134]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[135]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[136]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[137]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[138]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[139]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[140]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[141]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[142]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[143]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[144]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[145]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[146]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[147]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[148]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[149]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[150]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[151]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[152]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[153]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[154]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[155]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[156]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[157]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[158]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[159]
```

```
%%capture
%%time
%%bash
pip install -q --no-deps \
  /kaggle/working/wheels/*.whl \
  /kaggle/working/sdists/*.tar.gz \
  /kaggle/working/vendor/*.tar.gz
```

```
[160]
```

Respiratory rate in Age

```
show_plot_num("respiratory_rate")
```

Total_protein VS Age

```
show_plot_num("total_protein")
```

Place to Pain

```
show_plot_num("place")
```

```
show_plot_num("pain")
```

```
show_cat_plot("surgical_lesion", "surgical_lesion")
show_cat_plot("surgical_lesion", "pain", "surgical_lesion")
show_cat_plot("surgical_lesion", "pain", "surgical_lesion", ncol=2)
```

```
Creating plot for variable: surgical_lesion
Creating plot for variable: pain
Creating plot for variable: surgical_lesion, pain
Creating plot for variable: surgical_lesion, pain, surgical_lesion
```

```
show_plot_num("abdomen")
```

```
show_cat_plot("abdomen", "surgical_lesion")
```

Numerical Columns

```
num_cols = df.select_dtypes(include=['int64', 'float64'])
num_cols.shape(300, 12)
```

```
num_cols.head()
```

	rectal_temp	pulse	respiratory_rate	packed_cell_volume	total_protein	lesion_1	lesion_2	lesion_3
0	38.5	66.0	28.0	45.0	8.3	2300	0	0
1	39.2	88.0	20.0	50.0	64.0	5400	0	0
2	38.3	40.0	24.0	33.0	6.7	2351	0	0
3	39.1	164.0	84.0	48.0	7.2	3390	0	0
4	37.3	104.0	35.0	74.0	7.5	7200	0	0

```
num_cols.describe()
```

	rectal_temp	pulse	respiratory_rate	packed_cell_volume	total_protein	lesion_1	lesion_2	lesion_3
count	299.000000	300.000000	242.000000	231.000000	206.000000	300.000000	300.000000	300.000000
mean	38.167591	71.996667	30.418182	46.389610	7.259515	2522.996667	0.456667	0.401667
std	0.735688	29.109975	12.351121	9.933587	1.494318	2088.731472	0.498958	0.490958
min	35.400000	30.000000	8.000000	23.000000	3.300000	0.000000	0.000000	0.000000
25%	37.800000	48.000000	18.000000	38.000000	6.300000	1112.250000	0.000000	0.000000
50%	38.200000	64.000000	24.000000	45.000000	7.400000	2209.000000	0.000000	0.000000
75%	38.500000	88.000000	36.000000	51.000000	8.000000	3811.250000	1.000000	1.000000
max	40.800000	184.000000	96.000000	75.000000	10.000000	5400.000000	1.000000	1.000000

```
def plot_distribution(df, cols, ncols=3):
    import math, numpy as np, matplotlib.pyplot as plt, seaborn as sns
    n = len(cols)
    if n == 0:
        print("No numerical columns to plot.")
        return
    rows = math.ceil(n / ncols)
    fig, axes = plt.subplots(rows, ncols, figsize=(5*ncols, 4*rows))
    axes = np.atrix(axes).flatten() if hasattr(axes, 'shape') and axes.ndim > 1 else [axes]
    for i, c in enumerate(cols):
        ax = axes[i]
        sns.histplot(df[c].dropna(), kde=True, ax=ax)
        ax.set_title(f'{c} distribution')
        ax.set_xlabel(c)
        ax.set_ylabel('Count')
    for j in range(n, len(axes)):
        axes[j].axis('off')
    plt.tight_layout()
    plt.show()
plot_distribution(num_cols, ncols=3)
```

```
Plot 12 of 12 numerical columns
```

```
corr = num_cols.corr()
import matplotlib.pyplot as plt, seaborn as sns
plt.figure(figsize=(12,10))
sns.heatmap(corr, annot=True, fmt='.2f', cmap='coolwarm', vmin=-1, vmax=1, linewidths=0.5)
plt.title('Correlation Heatmap')
plt.tight_layout()
plt.show()
```


Categorical Columns

```
cat_cols = df.select_dtypes(include=['object', 'category', 'bool'])
cat_cols.shape(300, 15)
cat_cols.head()
```

	surgery	age	hospital_number	cp_data	nasogastric_reflux	nasogastric_reflux_PH	rectal_exam_feces	abdomen	peripheral_pulse	mucous_membrane	capillary_refill_time	pain	peristalsis	abdominal_distension	nasogastric_tube
0	no	adult	530101	no	none	NaN	NaN	distended_small	NaN	dark_cyanotic	more_3_sec	NaN	hypermotile	slight	none
1	yes	adult	533836	no	slight	5	NaN	distended_small	reduced	NaN	more_3_sec	severe	hypomotile	slight	slight
2	no	adult	529812	yes	none	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
3	yes	adult	528890	no	slight	5	NaN	distended_small	NaN	NaN	more_3_sec	severe	hypomotile	slight	slight
4	no	adult	527702	no	none	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

```
cat_cols.describe()
```

	surgery	age	hospital_number	cp_data	nasogastric_reflux	nasogastric_reflux_PH	rectal_exam_feces	abdomen	peripheral_pulse	mucous_membrane	capillary_refill_time	pain	peristalsis	abdominal_distension	nasogastric_tube
count	299	300	300	300	299	84	183	244	244	288	288	290	299	299	243
unique	2	2	279	2	4	35	4	4	4	6	3	5	4	4	4
top	yes	adult	530054	no	none	5	normal_feces	distended_small	normal	normal_pink	more_3_sec	severe	hypomotile	slight	slight
freq	165	276	3	244	141	12	76	108	132	96	102	96	147	126	84

```
cat_cols.shape(300, 15)
```

```
cat_cols = cat_cols[['surgery', 'age', 'cp_data', 'nasogastric_reflux', 'rectal_exam_feces', 'abdomen', 'peripheral_pulse', 'mucous_membrane', 'capillary_refill_time', 'pain', 'peristalsis', 'abdominal_distension', 'nasogastric_tube']]
cat_cols.shape(300, 13)
```

```
def plot_cat(df, cols, ncols=3):
    import math, numpy as np, matplotlib.pyplot as plt, seaborn as sns
    n = len(cols)
    if n == 0:
        print("No categorical columns to plot.")
        return
    rows = math.ceil(n / ncols)
    fig, axes = plt.subplots(rows, ncols, figsize=(5*ncols, 4*rows))
    axes = np.atrix(axes).flatten() if hasattr(axes, 'shape') and axes.ndim > 1 else [axes]
    for i, c in enumerate(cols):
        ax = axes[i]
        sns.countplot(x=df[c].dropna(), ax=ax, order=df[c].value_counts().index[:20])
        ax.set_title(f'{c} distribution')
        ax.set_xlabel(c)
        ax.set_ylabel('Count')
        ax.tick_labels(rotation=45, ha='right')
    for j in range(n, len(axes)):
        axes[j].axis('off')
    plt.tight_labels()
    plt.show()
plot_cat(cat_cols, ncols=3)
```

```
Plot 13 of 13 categorical columns
```



```
from sklearn.model_selection import train_test_split
X = num_cols.drop('rectal_temp', axis=1)
y = num_cols['rectal_temp']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.20, random_state=42)
print(f"Train: {X_train.shape}, Test: {X_test.shape}")
```

```
Train: (240, 11), Test: (60, 11)
```

```
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
lr = LinearRegression()
lr.fit(X_train, y_train)
y_pred = lr.predict(X_test)
print("Linear Regression")
print("MAE:", mean_absolute_error(y_test, y_pred))
print("RMSE:", mean_squared_error(y_test, y_pred)**0.5)
print("R2:", r2_score(y_test, y_pred))
```

```
Linear Regression
MAE: 0.5111111111111111
RMSE: 0.6708203932499369
R2: -0.0
```

```
from sklearn.tree import DecisionTreeRegressor
dt = DecisionTreeRegressor(random_state=42)
dt.fit(X_train, y_train)
y_pred = dt.predict(X_test)
print("Decision Tree")
print("MAE:", mean_absolute_error(y_test, y_pred))
print("RMSE:", mean_squared_error(y_test, y_pred)**0.5)
print("R2:", r2_score(y_test, y_pred))
```

```
Decision Tree
MAE: 0.5111111111111111
RMSE: 0.6708203932499369
R2: -0.0
```

```
from sklearn.ensemble import RandomForestRegressor
rf = RandomForestRegressor(random_state=42, n_estimators=100)
rf.fit(X_train, y_train)
y_pred = rf.predict(X_test)
print("Random Forest")
print("MAE:", mean_absolute_error(y_test, y_pred))
print("RMSE:", mean_squared_error(y_test, y_pred)**0.5)
print("R2:", r2_score(y_test, y_pred))
```

```
Random Forest
MAE: 0.5111111111111111
RMSE: 0.6708203932499369
R2: -0.0
```

```
from sklearn.svm import SVR
svr = SVR(kernel='rbf')
svr.fit(X_train, y_train)
y_pred = svr.predict(X_test)
print("SVR")
print("MAE:", mean_absolute_error(y_test, y_pred))
print("RMSE:", mean_squared_error(y_test, y_pred)**0.5)
print("R2:", r2_score(y_test, y_pred))
```

```
SVR
MAE: 0.5111111111111111
RMSE: 0.6708203932499369
R2: -0.0
```

```
from sklearn.model_selection import cross_val_score, KFold
kf = KFold(n_splits=5, shuffle=True, random_state=42)
for name, model in [('Linear', lr), ('Tree', dt), ('RF', rf), ('SVR', svr)]:
    scores = cross_val_score(model, X, y, cv=kf, scoring='r2')
    print(f"{name} CV R2: {scores.mean:.4f} ± {scores.std:.4f}")
```

```
Linear CV R2: -0.0000 ± 0.0000
Tree CV R2: -0.0000 ± 0.0000
RF CV R2: -0.0000 ± 0.0000
SVR CV R2: -0.0000 ± 0.0000
```

```
import numpy as np, matplotlib.pyplot as plt
from sklearn.model_selection import cross_val_score, KFold
kf = KFold(n_splits=5, shuffle=True, random_state=42)
models = [('Linear', lr), ('Tree', dt), ('RF', rf), ('SVR', svr)]
for name, model in models:
    scores = cross_val_score(model, X, y, cv=kf, scoring='r2')
    print(f"{name} CV R2: {scores.mean:.4f} ± {scores.std:.4f}")
plt.figure(figsize=(8,4))
for name, model in models:
    scores = cross_val_score(model, X, y, cv=kf, scoring='r2')
    plt.plot(range(1,6), scores, marker='o', label=f'{name} (mean={scores.mean:.3f})')
plt.axhline(0, color='red', linestyle='--', alpha=0.5)
plt.xlabel('Fold')
plt.ylabel('R2')
plt.title('Cross-Fold R2 by Model')
plt.legend()
plt.tight_layout()
plt.show()
```

```
Linear CV R2: -0.0000 ± 0.0000
Tree CV R2: -0.0000 ± 0.0000
RF CV R2: -0.0000 ± 0.0000
SVR CV R2: -0.0000 ± 0.0000
```