Understanding handgrip strength of humans

using light sensors

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About & Goal

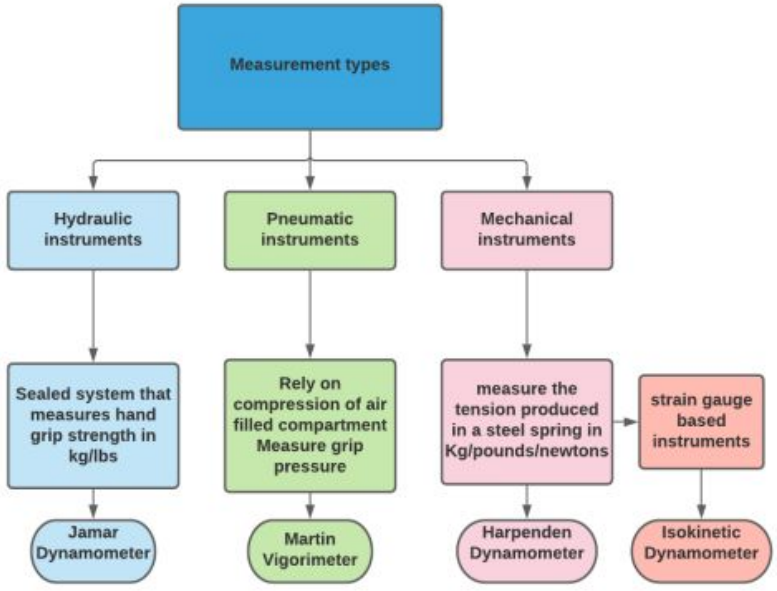
In this project, a dataset that contains the handgrip strength of multiple participants is provided. The overall goal is to analyze the data, categorize handgrip strength and create a deep learning prediction model to identify individuals.

Introduction

Increasing the population of the world can cause different serious problems. One of the these problems is growing the elderly people and most of them have several chronic diseases, frailty and other health challenges.

Materials and Method

The three basic principles for all types of measurement devices being used (fig 1):



(Illustration: Shivangi Saha)

Our experiments

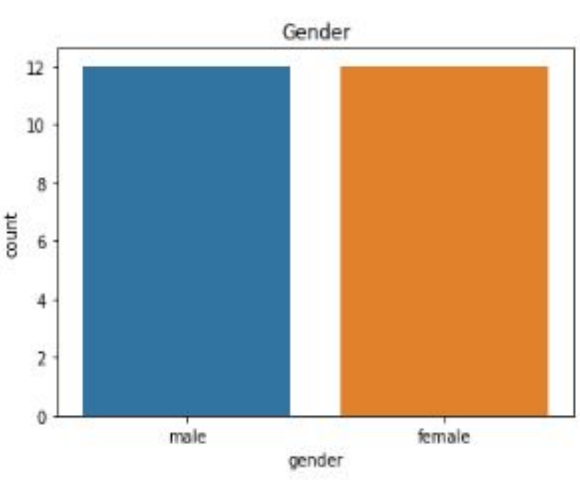
Exploratory Data Analysis

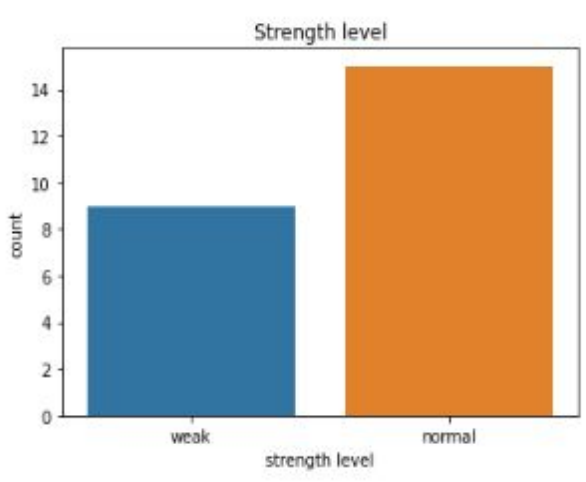
of experimented data

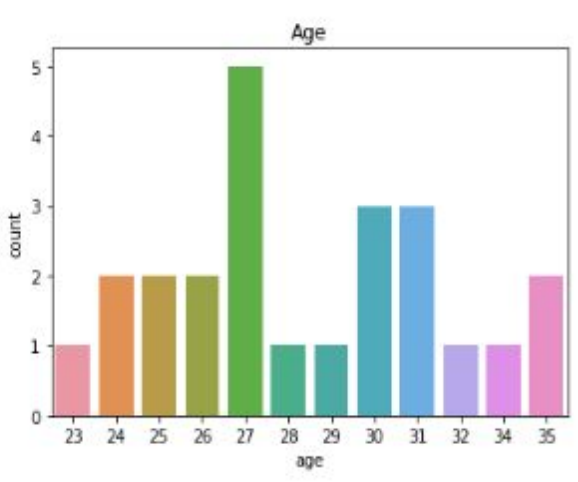
5 examples of the data:

id	gender	age	dynamometer(kg)	strength level	left-light	mid-light	right-light	size	length	width
5	male	35	30.80	weak	299.696450	174.567718	184.069000	140.80	17.6	8.0
11	female	26	26.70	normal	595.220500	190.450000	131.256300	141.04	17.2	8.2
12	male	30	42.30	normal	514.531250	383.863272	228.126872	175.50	19.5	9.0
4	female	31	14.50	weak	378.248400	418.451900	321.544776	122.50	17.5	7.0
23	male	26	43.05	normal	657.672834	442.571000	202.081500	164.90	19.4	8.5

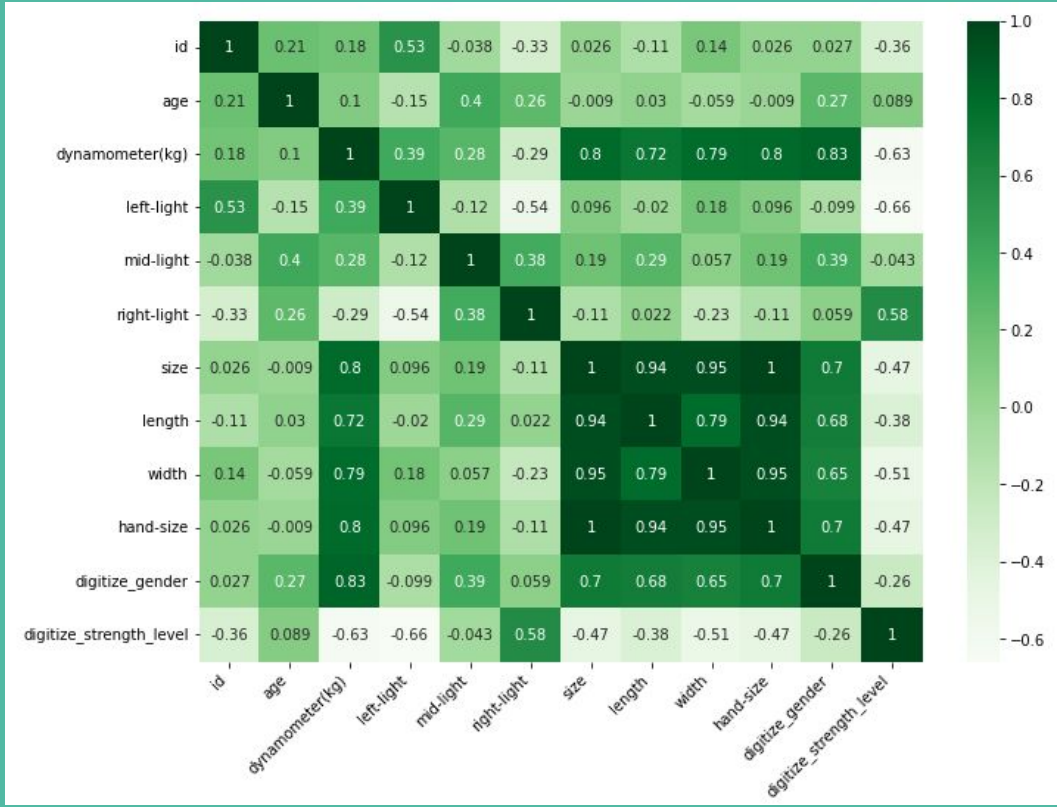
Gender, Strength and Age distribution







Confusion Matrix



Feature importance

Logistic Regression - Baseline Model

strength vs left-light sensor

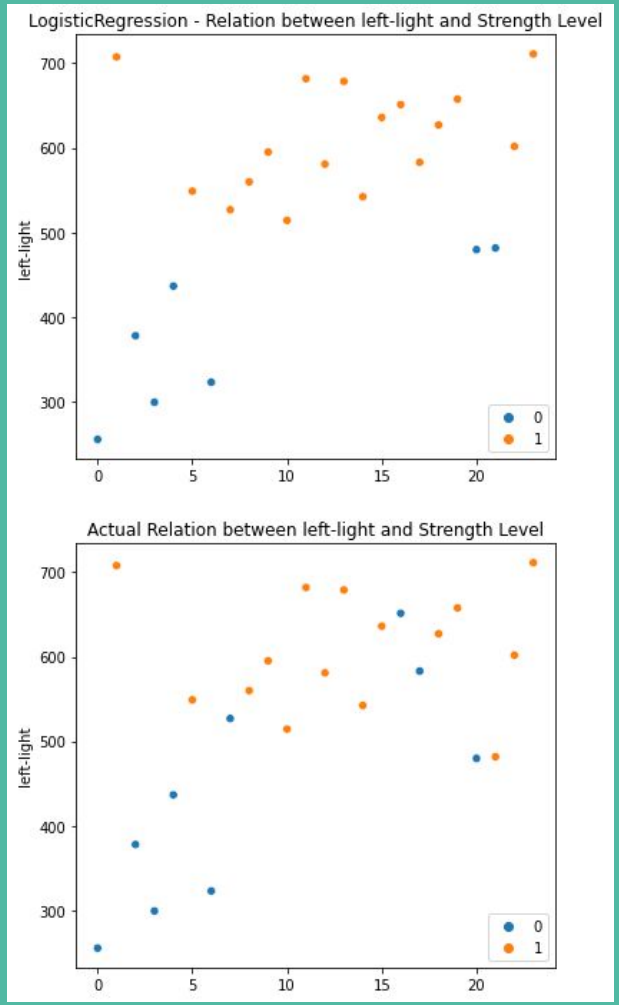
weak=False or normal=True

I have experimented LogisticRegression ML model and my feature is ***'left-light'*** sensor on the finger.

Trained model can predict strength level of the input feature with 83.33% accuracy.

From the graph, we can see that if the left-light sensor value is more than approximately 500 then model can predict that the person's strength level is normal, otherwise the strength level is weak.

	precision	recall	f1-score	support
0	0.86	0.67	0.75	9
1	0.82	0.93	0.87	15
accuracy			0.83	24
macro avg	0.84	0.80	0.81	24
weighted avg	0.84	0.83	0.83	24



strength vs mid-light sensor

weak=False or normal=True

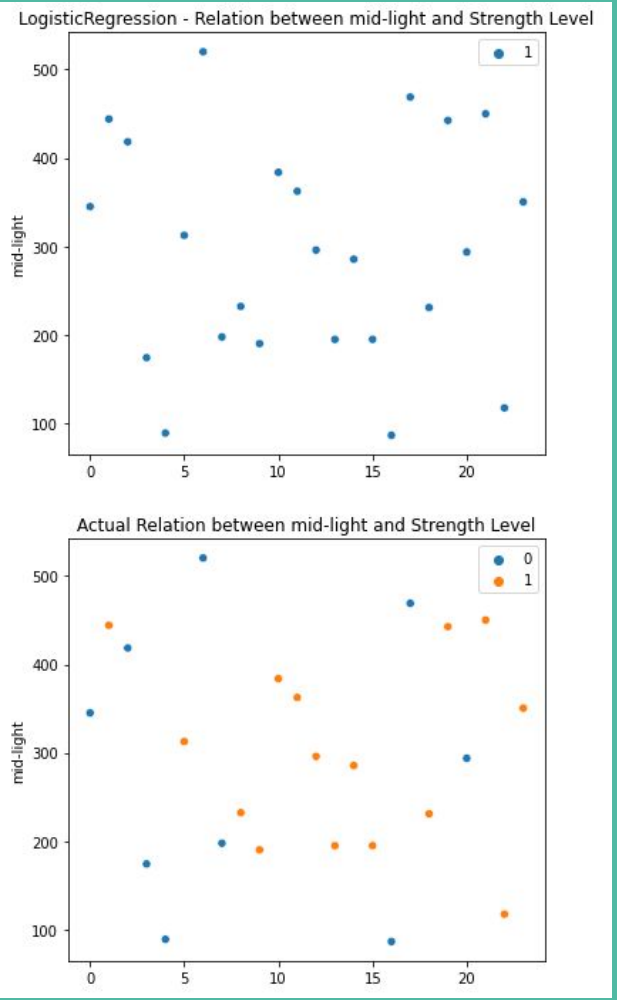
I have experimented LogisticRegression ML model and my feature is '***mid-light***' sensor on the finger.

Trained model can predict strength level of the input feature with 62.5% accuracy.

From the graph, we can see that the mid-light sensor value is not important feature for measuring strength level.

If we look f1-score for each unique prediction value, we see that model predicted all weak class as incorrectly.

	precision	recall	f1-score	support
0	0.00	0.00	0.00	9
1	0.62	1.00	0.77	15
accuracy			0.62	24
macro avg	0.31	0.50	0.38	24
weighted avg	0.39	0.62	0.48	24



strength vs right-light sensor

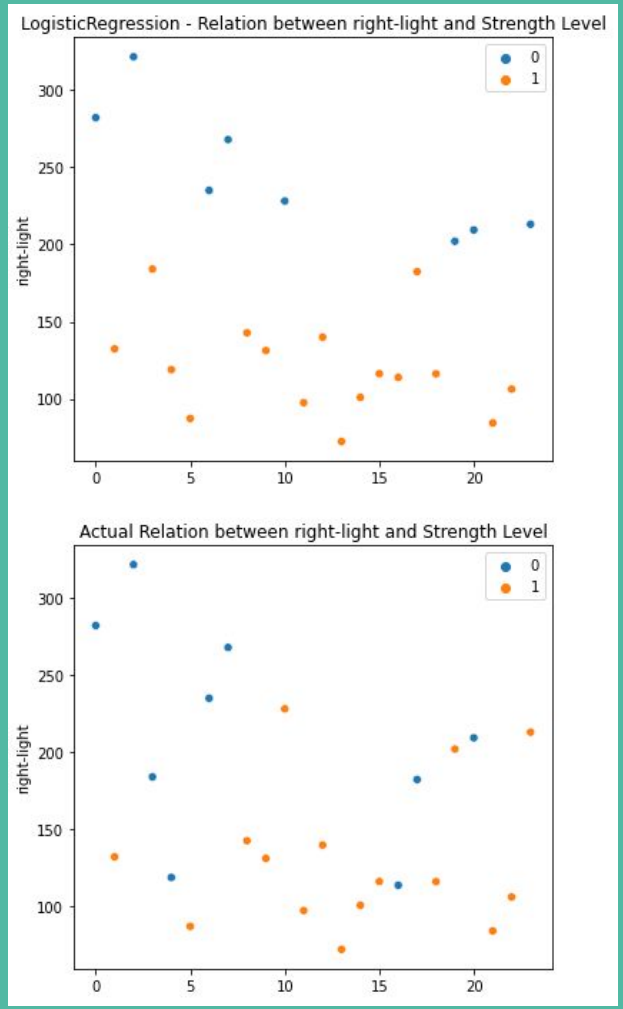
weak=False or normal=True

I have experimented LogisticRegression ML model and my feature is ***'right-light'*** sensor on the finger.

Trained model can predict strength level of the input feature with 70.83% accuracy.

From the graph, we can see that if the right-light sensor value is smaller than approximately 200 then model can predict that the person's strength level is normal, otherwise the strength level is weak.

	precision	recall	f1-score	support
0	0.62	0.56	0.59	9
1	0.75	0.80	0.77	15
accuracy			0.71	24
macro avg	0.69	0.68	0.68	24
weighted avg	0.70	0.71	0.70	24



RandomForestClassifier

strength vs left-light sensor

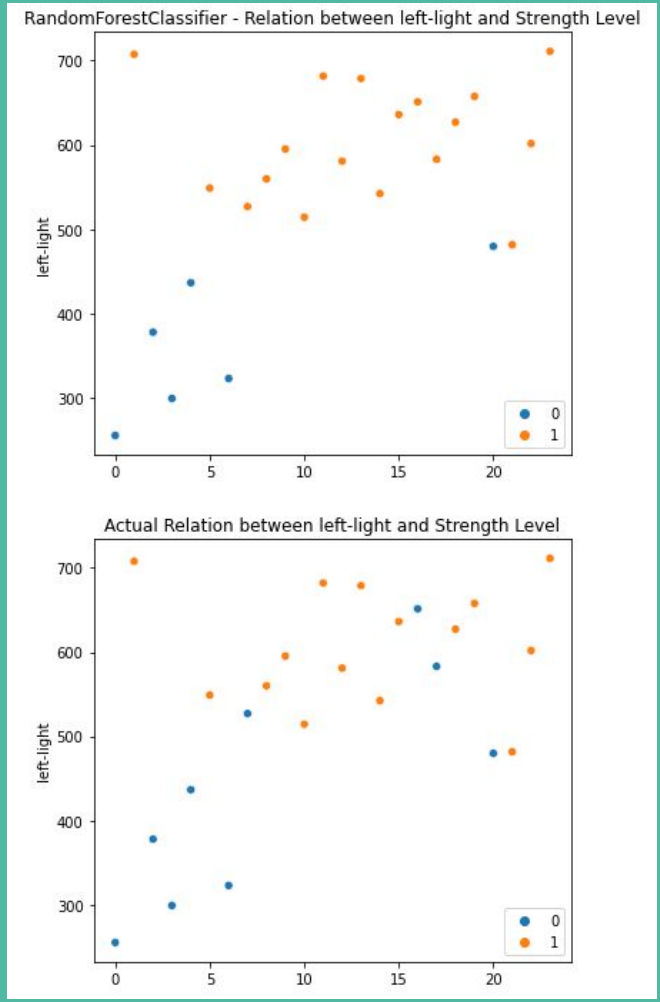
weak=False or normal=True

I have experimented RandomForestClassifier ML model and my feature is ***'left-light'*** sensor on the finger.

Trained model can predict strength level of the input feature with 87.5% accuracy.

From the graph, we can see that if the left-light sensor value is more than approximately 500 then model can predict that the person's strength level is normal, otherwise the strength level is weak.

	precision	recall	f1-score	support
0	1.00	0.67	0.80	9
1	0.83	1.00	0.91	15
accuracy			0.88	24
macro avg	0.92	0.83	0.85	24
weighted avg	0.90	0.88	0.87	24



strength vs mid-light sensor

weak=False or normal=True

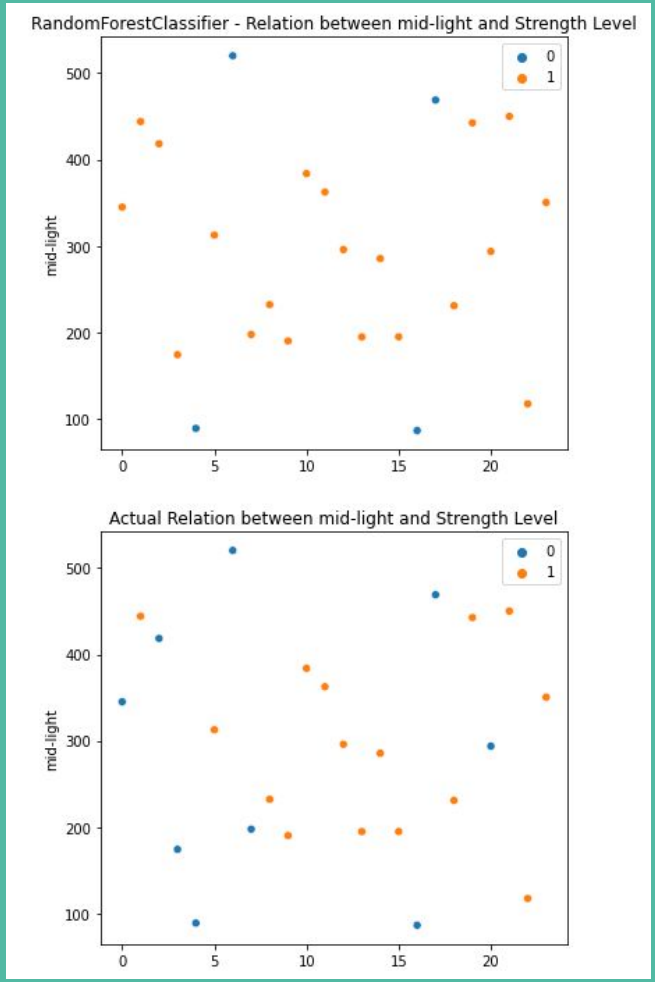
My experimented feature is ***'mid-light'*** sensor on the finger.

Trained model can predict strength level of the input with 79.2% accuracy.

We see that the accuracy is increased and precision, recall, f1-score has changed positively.

So, applying Random Forest Classifier to this problem is more relevant.

	precision	recall	f1-score	support
0	1.00	0.44	0.62	9
1	0.75	1.00	0.86	15
accuracy			0.79	24
macro avg	0.88	0.72	0.74	24
weighted avg	0.84	0.79	0.77	24



strength vs right-light sensor

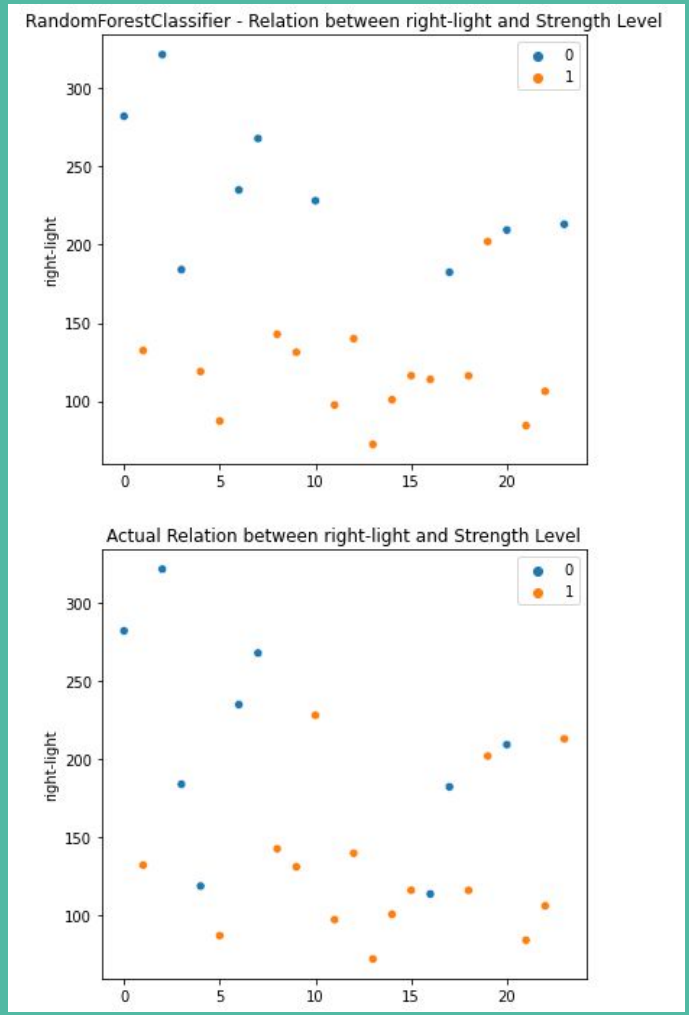
weak=False or normal=True

Now, I have tested ***right-light*** sensor feature as an input.

Trained model can predict strength level of the input feature with 83.33% accuracy.

From the graph, we can see that if the right-light sensor value is smaller than approximately 150 then model can predict that the person's strength level is normal, otherwise the strength level is weak.

	precision	recall	f1-score	support
0	0.78	0.78	0.78	9
1	0.87	0.87	0.87	15
accuracy			0.83	24
macro avg	0.82	0.82	0.82	24
weighted avg	0.83	0.83	0.83	24



Experiment more features

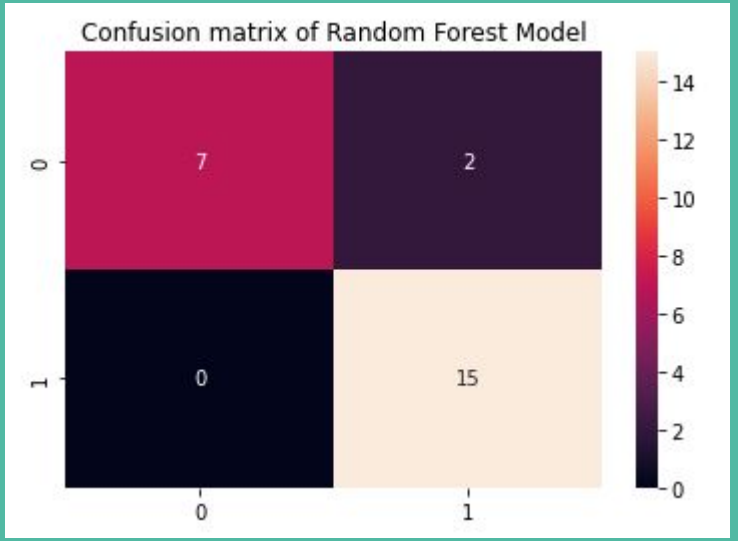
strength vs 4 features

weak = 0 or normal = 1

In this experiment, I have used 4 features as an input - l***eft-light***, ***mid-light***, ***right-light*** and ***age***.

The model accuracy is 91.6% at this time.

The model failed only 2 times - incorrectly predicted weak result as normal.



	precision	recall	f1-score	support
0	1.00	0.78	0.88	9
1	0.88	1.00	0.94	15
accuracy			0.92	24
macro avg	0.94	0.89	0.91	24
weighted avg	0.93	0.92	0.91	24

strength vs 5 features

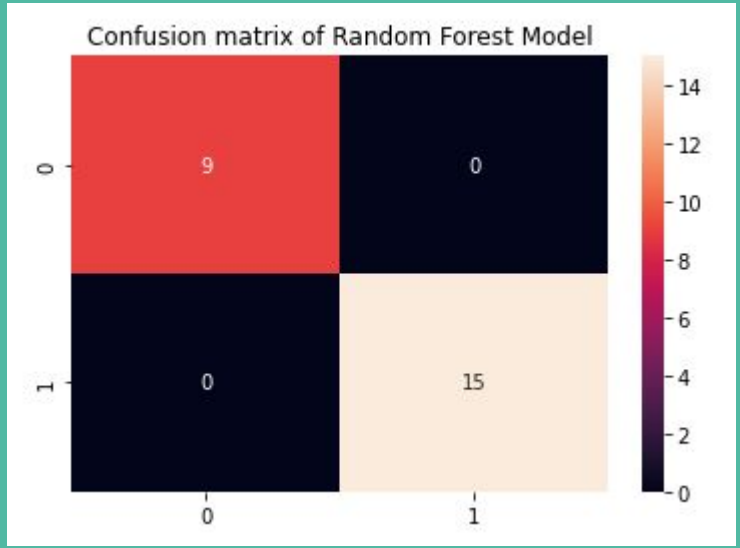
weak = 0 or normal = 1

In this experiment, I have used 5 features as an input - l***eft-light***, ***mid-light***, ***right-light***, ***age*** and ***hand-size***.

The model accuracy is 100% at this time.

So, using more features can increase model performance of RandomForestClassifier model.

The model has never failed .



	precision	recall	f1-score	support
0	1.00	1.00	1.00	9
1	1.00	1.00	1.00	15
accuracy			1.00	24
macro avg	1.00	1.00	1.00	24
weighted avg	1.00	1.00	1.00	24

Conclusion

This project can provide a good resolution for localized pathologies and offers better understanding the bio-structures of the impaired hands. Sex and hand length can significantly influence to the hand strength. In the future, based on this research, doctors can easily identify the injured hand without loosing important time.

References

https://www.issh.org/pdf/monthly_updates/Grip_Strenght_Evaluation_In_Hand_Suregry.pdf

https://www.researchgate.net/publication/323181938_Parameters_influencing_hand_grip_strength_measured_with_the_manugraphy_system

https://www.uhs.nhs.uk/Media/Southampton-Clinical-Research/Procedures/BRCProcedures/Procedure-for-measuring-gripstrength-using-the-JAMAR-dynamometer.pdf