Project by- **Ashish Verma**[15Mi423],**Vivek Thakur**[15MI424]

Objective: <u>Estimation of the Drain Source Current in the MOSFET(n-Channel)</u>

Mathodology: The current in the MOSFET depends upon following parameters-

- **Z** - The width of the transistor (only applies if K is calculated).
- **L** - The gate length of the transistor (only applies if K is calculated).
- μ_n - The electron mobility of the transistor substrate (only applies if Kis calculated).
- C_{ox} - The specific capacitance of the gate oxide (only applies if K is calculated).
- Vth: threshold voltage
- T_{ox} - The width of the gate oxide (only applies if Vth is calculated).
- E_{ox} - The relative permittivity of the gate oxide (only applies if Vth is calculated).
- N_A - The acceptor doping concentration (only applies if Vth is calculated).
- N_i - The intrinsic carrier concentration of the substrate at 300K (only applies if Vth is calculated).
- **T** - The temperature (only applies if Vth is calculated).
- V_{FB}
- The flat band voltage of the transistor (only applies if Vth is calculated).
- λ: channel length modulation
- The channel length modulation.
- V_{GS} The gate source voltage.

So the drain source current depends upon these parameters.

2. So from the datasheet table we took the values which are constrained to a definite limit and made a csv file.

3. Since there is a continuous value estimation(or prediction) we used the linear regression.

4. We used the LinearRegressor class in TensorFlow to predict the current(Ids), at the granularity of city blocks, based on one input feature

5. Evaluate the accuracy of a model's predictions using Root Mean Squared Error (RMSE).

6. Improve the accuracy of a model by tuning its hyperparameters.

Data Generation & Collection:

1. The following formulas are used data generation

$$I_{DS} = K\left[(V_{GS} - V_{th})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

$$V_{th}=\frac{2\epsilon t_{ox}}{\epsilon_{ox}}\sqrt{\frac{N_A k_B T}{\epsilon}\ln\left(\frac{N_A}{n_i}\right)} + 2\frac{k_B T}{e}\ln\left(\frac{N_A}{n_i}\right)+V_{FB}$$

$$I_{DS} = \frac{K}{2}(V_{GS} - V_{th})^2(1 + \lambda(V_{DS} - V_{sat}))$$

$$K = \frac{Z}{L}\mu_n C_{ox}$$

The first equation is used current estimation.

2. 1st equation contains the Vth which is estimated my nd equation

3.The 1st equation is for estimation of current while the mosfet is operated in linear region

4.3rd eq. Is used for estimation of current while in the saturation region of operation

The constant data are taken from the specification datasheet

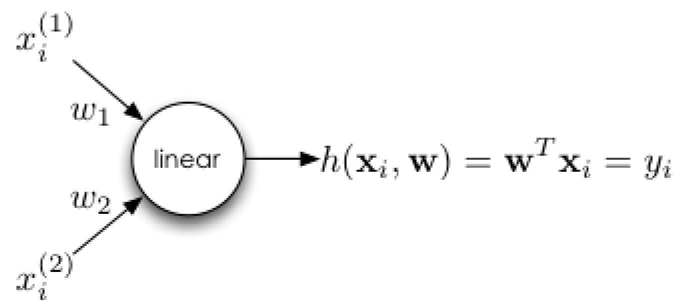
Below is a screenshot of dataset created

	B	C	D	E	F	G	H	I	J	K	L	M	N
1	L(Gate length-nm	e-mobility(u)	Cox(Gate Cap)	Tox	Eox	Na	Ni	T	Vfb	lamda	Vgs	Vds	Ids
2	9*10^(-9)	900	10^(-9)	3*10^(-9)	3	4*10^15	1.01*10^10	300	25*10^(-3)	0.05	3	0.25	0.0054
3	10*10^(-9)	910	20^(-9)	4*10^(-9)	3.1	5*10^15	1.11*10^10	301	26*10^(-3)	0.06	3.1	0.5	0.025
4	11*10^(-9)	920	30^(-9)	5*10^(-9)	3.2	5*10^15	1.20*10^10	302	27*10^(-3)	0.07	3.2	0.75	0.158
5	12*10^(-9)	930	40^(-9)	6*10^(-9)	3.3	6*10^15	1.30*10^10	303	28*10^(-3)	0.08	3.3	1	0.35
6	13*10^(-9)	940	50^(-9)	7*10^(-9)	3.4	7*10^15	1.40*10^10	304	29*10^(-3)	0.09	3.4	1.25	0.55
7	14*10^(-9)	950	60^(-9)	8*10^(-9)	3.6	8*10^15	1.50*10^10	305	30*10^(-3)	0.1	3.5	1.5	0.76
8	15*10^(-9)	960	70^(-9)	9*10^(-9)	3.7	9*10^15	1.60*10^10	306	31*10^(-3)	0.11	3.6	1.75	1
9	16*10^(-9)	970	80^(-9)	10*10^(-9)	3.8	4.1*10^15	1.70*10^10	307	32*10^(-3)	0.12	3.7	2	1.23
10	17*10^(-9)	980	90^(-9)	11*10^(-9)	3.9	4.2*10^15	1.80*10^10	308	33*10^(-3)	0.13	3.8	2.25	1.46
11	18*10^(-9)	990	100^(-9)	12*10^(-9)	4	4.3*10^15	1.90*10^10	309	34*10^(-3)	0.14	3.9	2.5	1.81
12	19*10^(-9)	1000	110^(-9)	13*10^(-9)	4.1	4.4*10^15	2*10^10	310	35*10^(-3)	0.16	4	0.25	0.36
13	20*10^(-9)	1110	120^(-9)	14*10^(-9)	4.2	4.5*10^15	2.10*10^10	311	36*10^(-3)	0.17	4.1	0.5	0.75
14	21*10^(-9)	1020	130^(-9)	15*10^(-9)	4.3	4.6*10^15	2.20*10^10	312	37*10^(-3)	0.18	4.2	0.75	1.2
15	22*10^(-9)	1030	140^(-9)	16*10^(-9)	4.4	4.7*10^15	2.30*10^10	313	38*10^(-3)	0.19	4.3	1	1.5
16	23*10^(-9)	1040	150^(-9)	17*10^(-9)	4.5	4.8*10^15	2.40*10^10	314	39*10^(-3)	0.2	4.4	1.25	1.8
17	24*10^(-9)	1050	160^(-9)	18*10^(-9)	4.6	5.1*10^15	2.50*10^10	315	40*10^(-3)	0.21	4.5	1.5	2.38
18	25*10^(-9)	1060	170^(-9)	19*10^(-9)	4.7	5.2*10^15	2.60*10^10	316	41*10^(-3)	0.22	4.6	1.75	2.25
19	26*10^(-9)	1070	180^(-9)	20*10^(-9)	4.8	5.3*10^15	2.70*10^10	317	42*10^(-3)	0.23	4.7	2	3.46
20	27*10^(-9)	1080	190^(-9)	21*10^(-9)	4.9	5.4*10^15	2.80*10^10	318	43*10^(-3)	0.24	4.8	2.25	4.4
21	28*10^(-9)	1090	200^(-9)	22*10^(-9)	5	5.6*10^15	2.90*10^10	319	44*10^(-3)	0.25	4.9	2.5	4.6
22	29*10^(-9)	1100	210^(-9)	23*10^(-9)	5.1	5.7*10^15	3*10^10	320	45*10^(-3)	0.26	5	2.75	5.2
23	30*10^(-9)	1110	220^(-9)	24*10^(-9)	5.2	5.8*10^15	3.10*10^10	321	46*10^(-3)	0.27	5.1	3	5.3
24	31*10^(-9)	1120	230^(-9)	25*10^(-9)	5.2	6*10^15	3.20*10^10	322	47*10^(-3)	0.28	5.2	3.25	5.4

Link:https://docs.google.com/spreadsheets/d/1PMxUIYQKfqvIlanc142LV-4h4qThXnTfjZ_2CICZP4o/edit?usp=sharing

Network Layers:

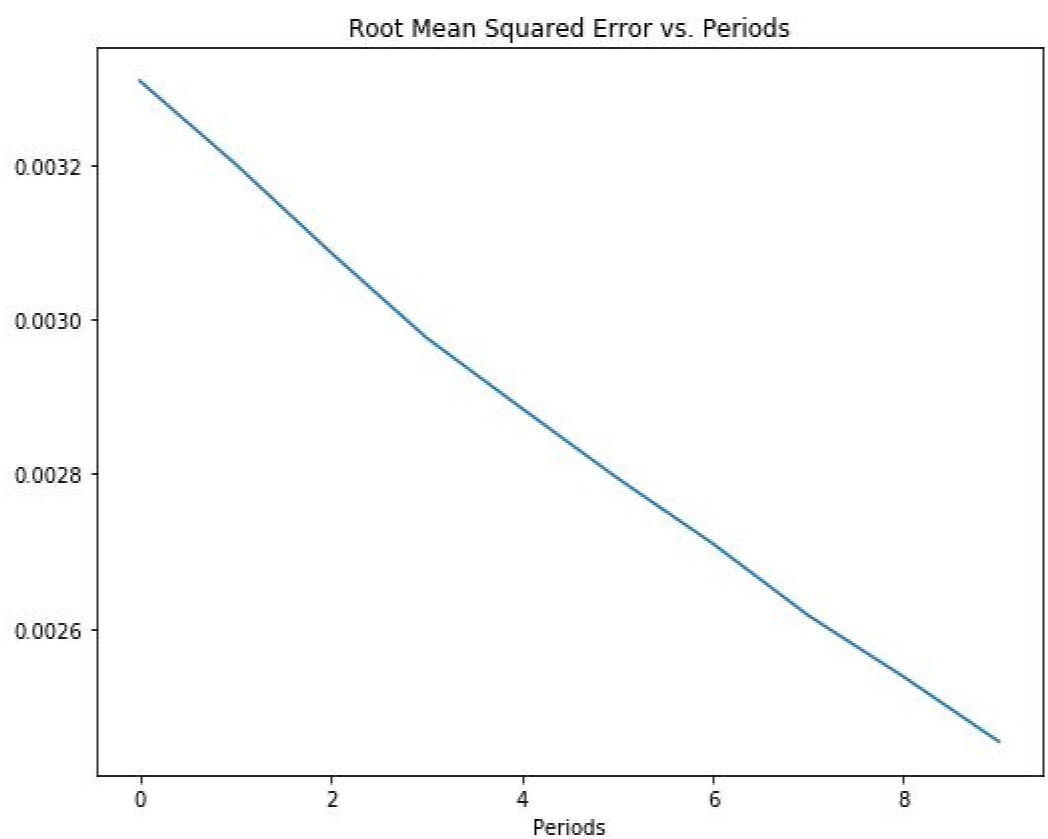
1. Since we are using Linear regression with the Loss function RMSE(Root mean square error) it can we said it’s just one neuron which is fed the values of parameter and it produces an output and finds the relation between the input



parameters and the output by minimising the error function.

2. Loss function $L(\mathbf{w})=\sum_i\left(h(\mathbf{x}_i,\mathbf{w})-y_i\right)^2$

Result: Reduction of the loss function with the periods



2. Estimation of current

```
# Call predict() on the linear_regressor to make predictions.
predictions = linear_regressor.predict(input_fn=4.5)#Value fed is the
Vds(Drain Source Voltage)
```

Current Val in milliamps is 3.67

The above value is predicted value. WHich is close to the estimated value 3.75 milliamps

Link to Colab: https://colab.research.google.com/drive/1R70PJExWWhggl-5r-sC3Eee-p-O4qo1x.