**Basic regression example in TF2: “Predict Fuel Efficiency”**

During the course we covered linear regression where our goal is to predict the output of a continuous variable, like a house price in the first assignment. This demo in TF2 is a very good example how are the concepts we learned during the course related to data preparation and measuring the MSE applied in TF for the model predictions.

Steps:

1. **Clean the dataset**

This TF example is using the “Auto MPG” Dataset and builds a model to predict the fuel efficiency of late-1970s and early 1980s automobiles.

This dataset includes features like cylinders, displacement, horsepower and weight. Your first task in ML is to “clean” the dataset and you do this by dropping the unknown values, (dropping the rows in which they appear).

The columns like the “Origin” column which are categorical and not numeric, we convert to a “one-hot encoding”, example is on the picture below where we assign an integer number to each country of origin and then TF maps this to the binary number in the columns:

![A close up of a keyboard

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coKSo0NTY3ODk6Q0RFRkdISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXqDhIWGh4iJipKTlJWWl5iZmqKjpKWmp6ipqrKztLW2t7i5usLDxMXGx8jJytLT1NXW19jZ2uHi4+Tl5ufo6erx8vP09fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAECAwQFBgcICQoL/8QAtREAAgECBAQDBAcFBAQAAQJ3AAECAxEEBSExBhJBUQdhcRMiMoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8RcYGRomJygpKjU2Nzg5OkNERUZHSElKU1RVVldYWVpjZGVmZ2hpanN0dXZ3eHl6goOEhYaHiImKkpOUlZaXmJmaoqOkpaanqKmqsrO0tba3uLm6wsPExcbHyMnK0tPU1dbX2Nna4uPk5ebn6Onq8vP09fb3+Pn6/9oADAMBAAIRAxEAPwD6IoqXyf8Aa/Sjyf8Aa/SgCKipfJ/2v0o8n/a/SgCKipfJ/wBr9KPJ/wBr9KAIqKl8n/a/Sjyf9r9KAIqKl8n/AGv0o8n/AGv0oAioqXyf9r9KPJ/2v0oAioqXyf8Aa/Sjyf8Aa/SgCKipfJ/2v0o8n/a/SgCKipfJ/wBr9KPJ/wBr9KAIqKl8n/a/Sjyf9r9KAIqKl8n/AGv0o8n/AGv0oAioqXyf9r9KPJ/2v0oAioqXyf8Aa/Sjyf8Aa/SgCKipfJ/2v0ooAkoorM1PxLoWi3CwaxrWnafM67ljurtImZfUBiOKANOikR1kjV42DIwyrKcgj1paACiiigAooooAKKRmCKWYhVAySTwBWdpniTQ9ameLRtZ0/UJUXc6Wl0krKPUhScCgDSooooAKKKKACiioZry2tpYIri4iikuH2QpI4UytgnaoPU4BOB2BoAmoqhc67pFlbzz3mq2VvDbSCKeSW4RVic4wrEnAPI4PPNPm1jTLbSxqdxqNpFYFQwu5J1WIg9DvJxg545oAuUUiOskavGwZGGVZTkEetLQAUUUUAFFFFABRRRQAUUUUAFeaeI9U/sr4viT+3tI0Tfoqr5uqx7kf98flX97Hz+J+lel0UAeT+OfEtxpk3i2FdWngmm0aCTTFhldd7/PveEA9uCSvQck4q+bbUvEfjPWtKTXdQsEj0izlt2t53Aimbf8AvMAjPTlc4bvnAx6TRQB5Lr2q30eo6/Fd6veQeILWWBNDsoLpohdLtX5hAG2yhn37shsAY4xUN3q9y+uaxFBr12dfh1yCKx0xL1iBEREZAYA2GjxvyWBAwcYNewVnaXotvpN1qM9s8rNqNz9plEhBCttVcLgDjCjrmgDzZtU1q48e3kEus2On30OrIkEF7rUkO+1+X5EtNmyXepOHyTuPUYxXrVFFACMwVSxzgDJwM1wFvq1pf/EnVdY0mcahaWOhiOWSyIkxJ5jN5YPTfgfdPI4zXoFFAHidj4ovbi51SXTb2RLS58O3F0BFrU1/5cy4IO9wBFIoflEOBke1aOm+I/sUVzqGmatf65YQ6CJ9SdL0z7LrIwFckrE2CxZVAwBnFeo6pp8WraTd6fcs6w3ULQu0ZAYKwwcZB55qSztUsbGC0iLGOCNY1LHkhRgZ9+KAPGI/EOprpfjFLDUZI7aGwtbi0lttXmv1jdnKsY7iUAn7uCBlQQR613PhN57Txz4g0g3l3c2sFvaTRi7uXmZXdW3kFicA4B2jAHYCu0ooAK47x3IlnqnhXUrt1hsbLVC9zcSMFSFWgkQMxPAG5gMnjkV2NFAHkDwWl7Pfa8niO10Hbr0l1pmo3SJJbXC+SkbDLEKQfmAIYHgkdDU0uu3/AIn0jw3ZX2hfaZbq4uLu6tdOCKs8URZVlTzmUbHZ1YZbJ969ZooA5T4bX0t34HtLe7R47rTmexnSRgWVomK84JGcAHgnrXV0UUAFFFFABRRRQAUUUUAFFFFAFXzLj+/F/wB+z/jR5lx/fi/79n/GlooATzLj+/F/37P+NHmXH9+L/v2f8aWigBPMuP78X/fs/wCNHmXH9+L/AL9n/GlooATzLj+/F/37P+NHmXH9+L/v2f8AGst/Eulx6v8A2a08n2jeIywt5DErkZCGXbsDEEfKWzyOORWrQAnmXH9+L/v2f8aPMuP78X/fs/40tFACeZcf34v+/Z/xo8y4/vxf9+z/AI0tFACeZcf34v8Av2f8aPMuP78X/fs/41HdXUFjaS3V3KsMEKF5JHOAoHU1V0vW7LWFkNk0waIgSRXFvJBIueQSkiq2D2OMHBoAveZcf34v+/Z/xo8y4/vxf9+z/jS0UAJ5lx/fi/79n/GjzLj+/F/37P8AjS1Be3ttp1jNeX06W9tAheSWRsKijqSaAJvMuP78X/fs/wCNWIyxjBcgt3wMCqlvPHdW0VxA2+KVA6NgjKkZB5q3H/qxQA6iiigAooooAKKKKACiiigCtRRRQAUUUUAFFFFAHnkt1bppd94eaSNdam1gyxWhk/eurXAkWUDqVCc7hwNpHavQ6KKACiiigAooooAwvGcTyeGJSkTSiGaGaREBJKJKrPwOvyg8d6raPf2mteMLvUdHuYbyxWxiga5t5A8byb3baCOCVB59NwrpqKACiiigArG8VadZ3/h28a9tYrg29vLLD5qBvLcIcMM9CPWtmigDP8P/APItaZ/16Rf+gCteP/VioKnj/wBWKAHUUUUAFFFFABRRRQAUUUUAM8pfU0eUvqafRQAzyl9TR5S+pp9FADPKX1NHlL6mn0UAM8pfU0eUvqay38UaUviaHQEuBNqEqszRxfMIQq7vnP8ACSOg6nrjHNa9ADPKX1NHlL6mn0UAM8pfU0eUvqafRQAzyl9TR5S+pqDUtRt9J06a9vGKwwrk7Rkk9AAO5JwAPU1V0nWxqc09vNYXenXcAV3trvy9+xs7WBjdlIOCOuRg5AoA0fKX1NHlL6mn0UAM8pfU0eUvqafWbq+tJpRt4ktLi+u7lisNra7PMfAyxy7KoAHUkjqB1IFAF/yl9TTlG1cCqul6lDq2npd26uisWVo5Bh43UlWVh6ggjjI44Jq3QAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAYGqWkjeMNAmgt2MUZuTLIiHapMYALEdM+9b9FFABRRRQAUUUUAYvi2zuL3w5KtnD580UsNwIh1kEciuVHuQpA96raPKdW8VXWrw211BaLZx2yNd2slu8j72ZvkkAbAyBnGCScdK6OigAooooAK53Xi+n+ItK1l7aee0gint5vs1u88kfmbCrbEBYjKYOAcZHbJroqKAMTwpbzRaXcT3ELW7Xl5NdLE67WRHcldw7HGCQeRnBrboooAKKKKACiiigAooooAKKKKAIPMb1/SjzG9f0ptFADvMb1/SjzG9f0ptFADvMb1/SjzG9f0ptFADvMb1/SjzG9f0rmJPFc63Us6afG2jw3Ys5Lw3OJBJuCEiLZgoHO0kuDwTjA56WgB3mN6/pR5jev6U2igB3mN6/pR5jev6U2igB3mN6/pR5jev6Vn6xqkejaVNeyo0mzCpGvWR2IVVGfViB+NVtJ1e7ub+40/V7KGzvoY1mCQXJnjeNiQCGKIcgqQRt9OTmgDZ8xvX9KPMb1/Sm0UAO8xvX9KPMb1/Sm1l6/rsPh/S5LuW3ubpwrGOC2iLs5AJ6gYUcfebAHrQBreY3r+lSoSUBNUNPuvt2m2t3s8v7RCkuzOdu4A4z361fj/wBWKAHUUUUAFFFFABRRRQAUUUUAVqKKKACiiigAooooA4yXStW8m50FbCR7W51A3I1ESRiNImlErKV3b9+cqMKR0OeuOzoooAKKKKACiiigDK8SafcanoUsFkV+0o8c0QY4DNG6uFJ7Z24z2zVbSYr691+41e/sJtNU2yW0VvO8bSHDFmY+WzKByAPmzweBW9RQAUUUUAFU9YgkutDvreBd8sttIiLkDLFSAOauUUAU9HgktdDsbeddksVtGjrkHDBQCOK04/8AVioKnj/1YoAdRRRQAUUUUAFFFFABRRRQAm1f7o/Kjav90flS0UAJtX+6Pyo2r/dH5UtFACbV/uj8qNq/3R+VLRQAm1f7o/Kjav8AdH5VycniTVQ0+qotoNGt777G8DQuZ3AkEbSiTdtADE/LsOQv3ueOtoATav8AdH5UbV/uj8qWigBNq/3R+VG1f7o/KlooATav90flRtX+6PyrO8Qao+j6LLdwxCabckUMZOA0jsEXJ7DLDPtVbSNQ1JdYuNJ1uS1nuI4EuI7i0gaFHRiVKlGd8EFeu7nI4FAG1tX+6Pyo2r/dH5UtFACbV/uj8qNq/wB0flS1k+JdWu9G0Wa607TZNQnVGZUDqiJhSdzsTwvHYE+goA1dq/3R+VKBjpVXS7p77R7O7lCiSeBJGCjgFlBOPbmrVABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQByUnhvVS0+lI1odGuL77Y87TOJ0BkEjRCPbtILA/NvGA33eOetoooAKKKKACiiigDN8QaW+saLLaQyiGbcksMhGQsiMHXI7jKjPtVbSNP1JtYuNW1uO1guJIEt47e0naZERSWLF2RMklum3jA5NbdFABRRRQAVV1S1e+0e8tIiokngeNSx4BZSBn25q1RQBV0u1ex0eztJSpkggSNip4JVQDj24q1RRQAUUUUAFFFFABRRRQAUUUUAVqKKKACiiigAooooAKK4yXVdW8m515b+RLW21A2w04RxmN4llETMW279+csMMB0GOuezoAKKKKACiiigAorK8SahcaZoUs9kF+0u8cMRYZCtI6oGI743Zx3xVbSZb6y1+40i/v5tSUWyXMVxOkayDLFWU+WqqRwCPlzyeTQBvUUUUAFFFY/ie71Wy0K4m0OK2adIncy3LkLEApO7aAd54+7kD3oA2Knj/1YrM0eeS60OxuJ23yy20bu2AMsVBJ4rTj/ANWKAHUUUUAFFFFABRRRQAUUUUAVqKXa390/lRtb+6fyoASil2t/dP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Now we can split the data into the training and test set and test set we will use for our model evaluation.

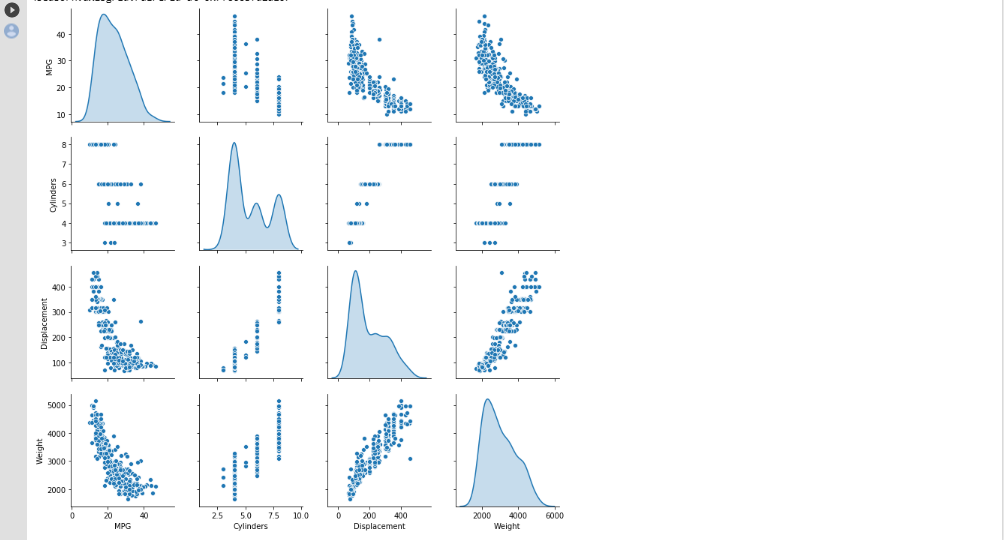
**2.** **Normaliize the data**

As we saw this before in the second assignment “input data normalization” is very important step in ML. When we inspect our dataset we will notice how different are ranges/units for each feature/label. Our model will not converge well and will not be robust to input data units changes if the scales and ranges of data are very different, hence the training will be more difficult. Your goal in ML is to have highly normalized dataset, even if that slows down the reporting performance at the end.

Next step is to inspect the dataset and we do this by creating the 2-dim plots of pairs of features, (columns from the dataset), including the MPG labels we will use for training

Although we intentionally generate these statistics from only the training dataset, these statistics will also be used to normalize the test dataset. We need to do that to project the test dataset into the same **distribution** that the model has been trained on, (topic of Proba&Stats course).

Here is an example of the picture you will get with joint distributions of some pairs from the training set:



1. **The Model: Build the Model and Train the model**

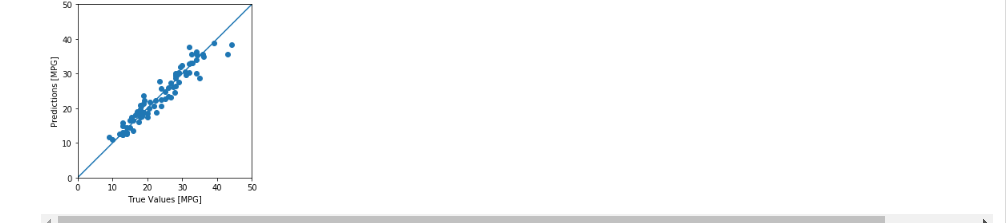
The steps in TF from 45 to 55 are showing how to build the model and do the training. They include concepts of deep learning we did not learn in this course, but you can go through the steps in Colab easily, and if there are issues report to DB thread. The program is drawing MAE, (Mean Average Error), and MSE during training and the later one will show you clear point when learning slows significantly, notice the knee on the curve in the example picture below. This is our metric to measure how good our regression model is.

![A close up of text on a white background

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1. **Predictions**

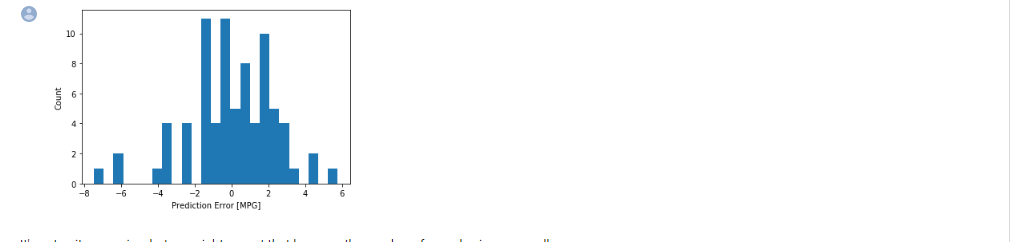
Finally, predict MPG values using data in the testing set:



Let us know in DB how good your predictions were.

1. **Prediction Error**

The last plot in demo is the prediction error (MPG), and how is it distributed upon the number of cases. Ideally Error Distribution should have gaussian shape, but in our case may not, as number of samples is limited. Here is an example of the graph you need to send back to DB week 9 thread as output result of your trial:



Thank you