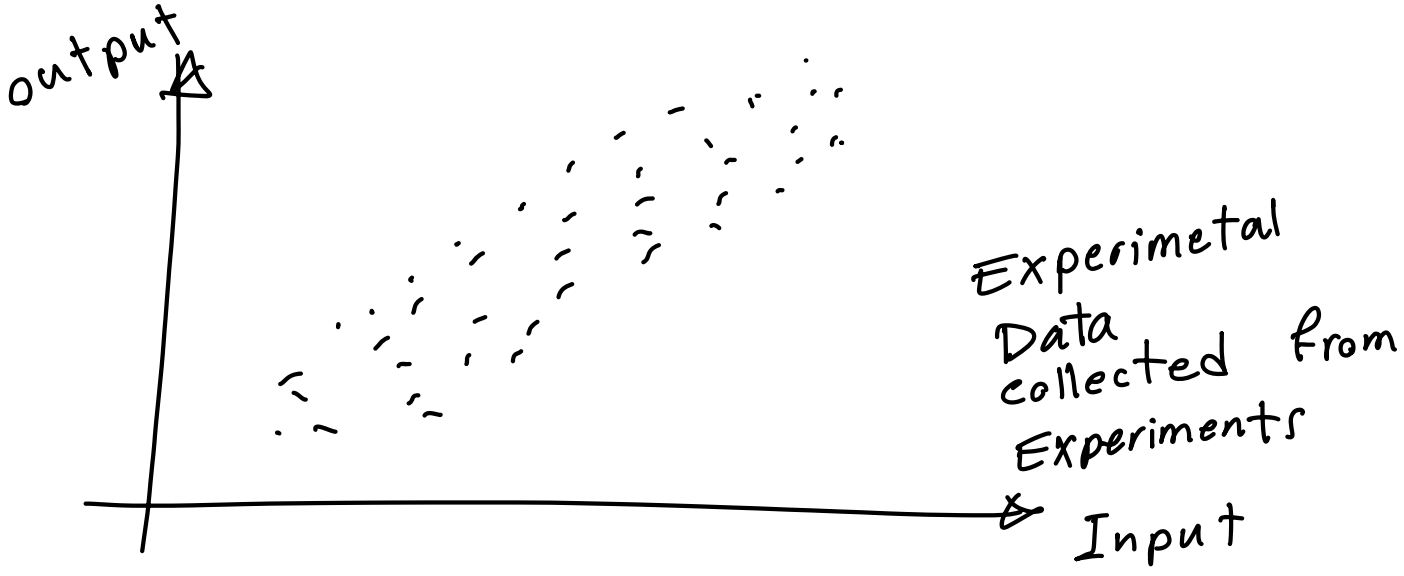
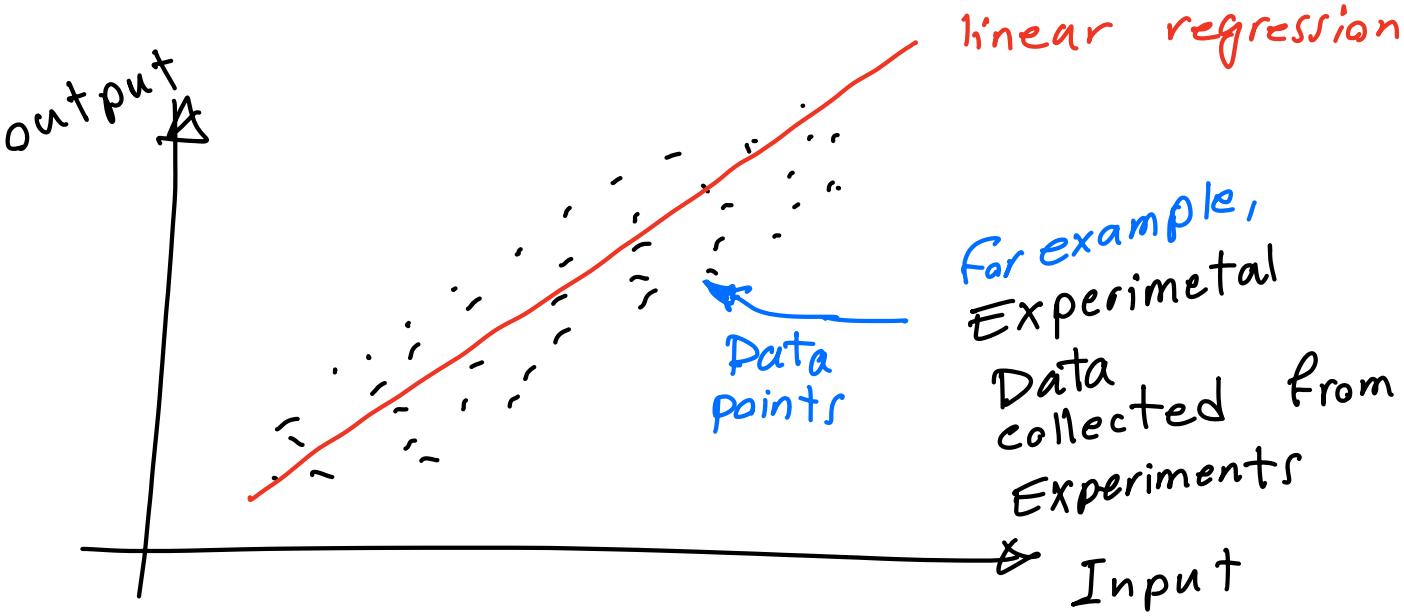
AI-Assisted control for Drones

Regression

Linear regression of data can provide a mathematical model of the data.



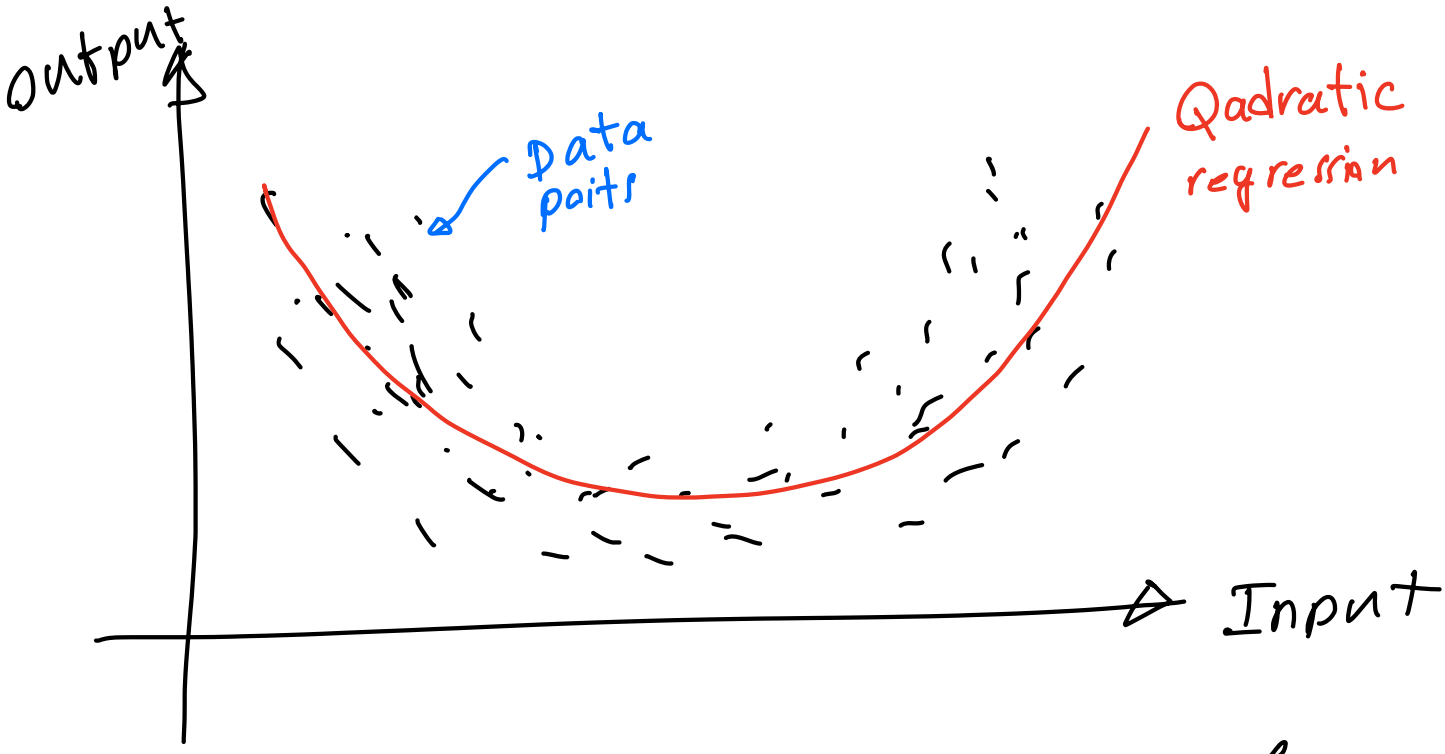
The goal is to find a linear function as the mathematical model of this data set.



The linear regression is obtained from the set of data points that has the overal minimum error with respect to the data points.

Quadratic regression

For more distributed data points a linear regression may not be sufficient to model the data. For example, for the following data set, a line may not be a good candidate to model the data. Therefor, a quadratic regression can



provide a more suitable model of the data.

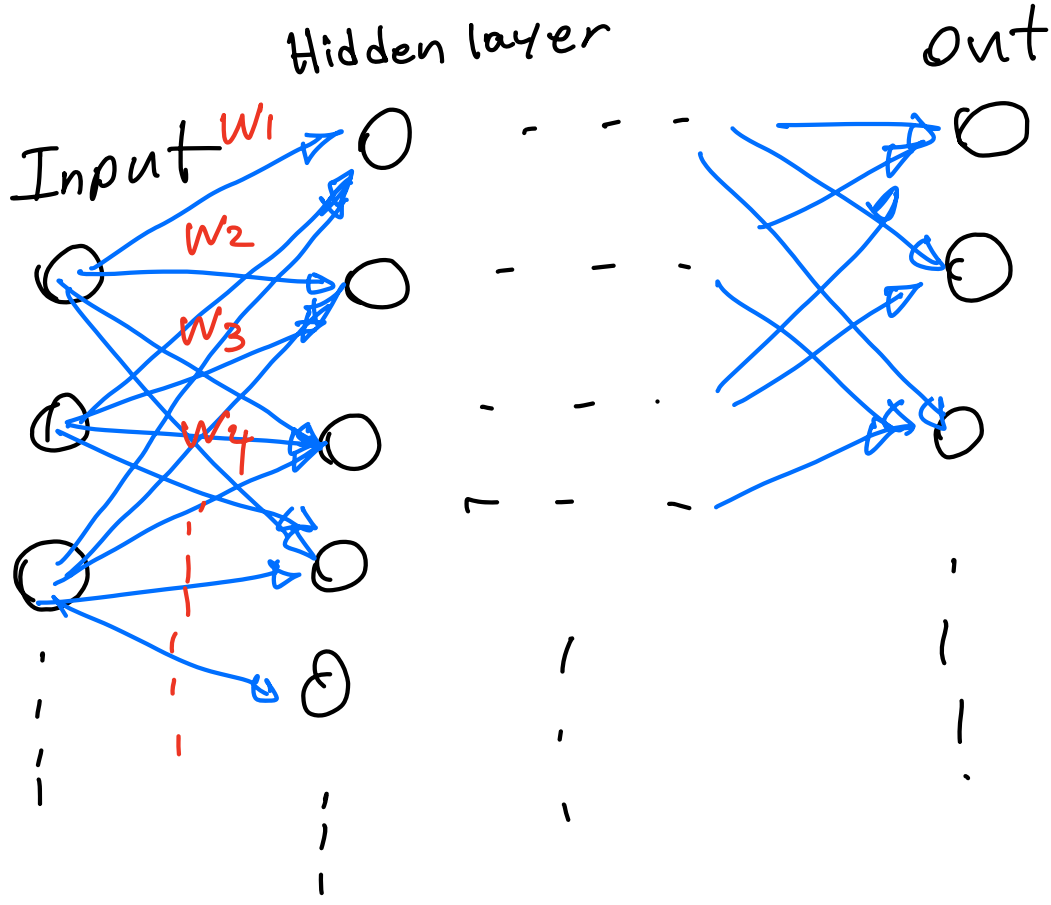
Artificial Neural Network (ANN)

ANN is a techniques used in machine learning and artificial intelligence.

ANN can be thought of a nonlinear regression that can provide a mathematical model of data sets.

Any data sets can be used as

"training data" to train the ANN.
The trained ANN is then the mathematical model of the data set. (similar to regression). There is no limit in the number of input and output data sets in ANN. This is one of the advantages of ANN.



The mathematical model is obtaind by finding the weights $w_1, w_2, w_3 \ldots, w_n$ that relate inputs

to the outputs. The general form of the mathematical model can be represented by:

$$h_j = a\sum_i (W_{ji} x_i + b_j)$$

weights — Input i

An example of using Machine Learning ANN in a control problem as below.

Example

Find PID controller gain values for controlling the motion of a drone. In a PID tuning problem, the controller may not be able to handle all the uncertainties in a real flight situation. An optimied control gain set (for PID terms) can be obtained as bellow.

1. Find the dynamics model of the drone.

2. Add uncertainties such as wind gust, payload, change in the power provided by the battery, Motor/propeller output changes over time, etc.

3. Use an optimization tool that can optimize the Gain terms in the simulation (such as, built-in functions in MATLAB, such, GA).

4. Run simulations of the Drone (including the uncertenties) for Varians input values.

5. for each set of input run the simution that gives optimal values

of the controller gains (e.g. using GA) and store the input and output data sets.

6. Use the stored input/output data sets to build the mathematial Model of the system using ANN (This can be done using built in functions of MATLAB.)

7. The ANN output is the optimal model of the system for optimal PID controller gains that give the least error in the response of the drone.

8. The above process is done off-line.

9. Now the optimized mathematical model

obtained from ANN and GA can be used on the control hardware

10. STM32 is a suitable microcontroller for implementing the ANN+GA PID controller. STM32 is an industry standard for UAV applications. Many flight controllers use STM32. (Teensy is faster than STM32 but it is not used in industry grade products/UAVs, and Arduino is not fast enough to perform the computational processes required in a drone control in real applications.)