Overloading in Robotic Arm and stress computation with MLP

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Abstract:

In this paper, a method has been proposed to analyze robotic arm overloading. Method used is MLP (multilayer preceptron). As robots are becoming norms of the industry, so some problem arises with their working. This paper gives a brief of hazards associated with robotic arm, with special emphasis laid on overloading in robotic arm. Method used firstly finds out the stress and then trains the system for risk management due to overloading in future use of robotic arm.

Keywords: Robotic Arm, Manipulator, Overloading, Neural networks, MLP, Stress .

1. INTRODUCTION

The industrial scenario is changing all over the world. Nowadays, in many parts of the world, human workforce has been replaced by robots in developed countries and same change is being seen in developing countries. Robots are identifiable as a unique device with computer aided design (CAD) systems and computer aided manufacturing (CAM) systems, designed to move material, parts tool or specialized devices through variable programmed motions to perform a variety of tasks [1]. As a result of the increased use of robots in human life, the safety of human's have become a hot issue in recent times, as with time many hazards have got associated with robotics. In this paper, overloading or stress on robotic arm has been studied, by implementing MLP [2]. Force has been calculated using FSR i.e."Force Sensing Resistor".

MLP i.e. Multilayer preceptron is a feed forward artificial neural network model that maps sets of input data onto a set of appropriate output. In earlier days, neural network approach has been used to find real time motion in robotic manipulator by Xianyi yang and Meng M (1999) which takes in consideration force[3]. Torque sensor based approach for robot arm control using disturbance observer by Hosun Lee, Yonghwan Oh and Jae-Bok Song (2010) has also been used, which refers to torque sensors.

2. MULTILAYER PERCEPTRON (MLP)

The adapted perceptrons are arranged in layers and so the model is termed as multilayer preceptron. This model has three layers: first an input layer and an output layer and a layer in between not connected directly to the input or the output and hence called hidden layer.

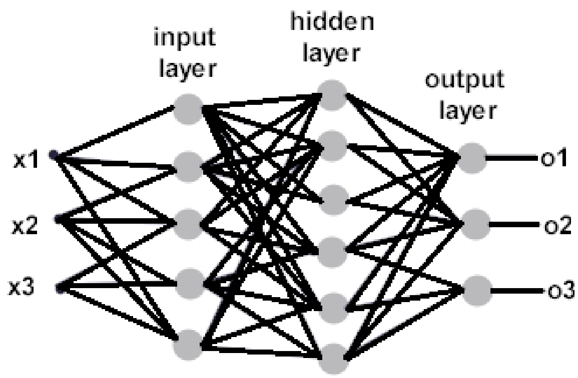


Fig 2: Multilayer Perceptron

For the perceptrons in the input layer, we use linear transfer function, and for the pereceptron in the hidden layer and the output layer we use sigmoidal or squashed-S functions [5]. The input layer serves to distribute the values they receive to the next layer and so, does not perform a weighted sum or threshold. Because we have modified a single layer preceptron by changing the non linearity from a step function to a sigmoidal function and added a hidden layer. So now, we have a network that should be able to learn to recognize more complex things.

3. HAZARDS ASSOCIATED WITH ROBOTS

The main hazard associated with the application of industrial robot is the working envelope of the robot[6]. The ability of the robot to move in free space which covers a wide area, change configuration and produce unexpected motion immediately can cause hazards to persons operating or standing in the vicinity of the robot. Malfunction and human error can lead to the unexpected movement of the industrial robot which includes:

a) Aberrant behavior of robots caused by control system faults.
b) Jamming of servo-valves.
c) Robot movement cutting its umbilical cord.
d) Splitting of unions on exposed hydraulic hoses.
e) Fault in data transmission causing a larger than anticipated movement of the robot arm.
f) Faults of welding gun and tooling parts.
g) Programming and other operational errors.
h) Precision deficiency, deterioration.
i) Incompatibility of jigs and other tools.

4. SENSORS

A sensor is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

4.1 Force-Sensing Resistor

A force-sensing resistor is a material whose resistance changes when a force or pressure is applied. They are also known as "force-sensitive resistor" and are sometimes referred to by the initialism "FSR". Force Sensing Resistors (FSR) are a Polymer thick film (PTF) device which exhibits a decrease in resistance with an increase in the force applied to the active surface. Its force sensitivity is optimized for use in human touch control of electronic devices [7]. FSRs are not a load cell or strain gauge, though they have similar properties. FSRs are suitable for precision measurements.

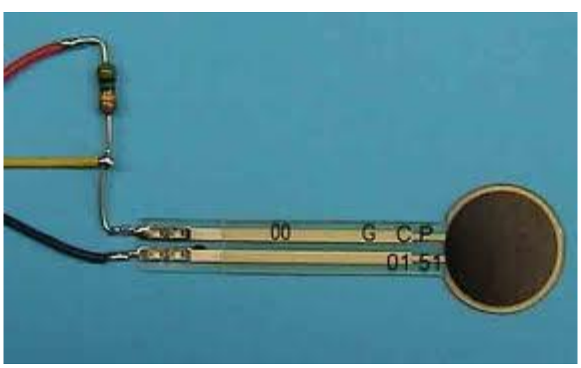
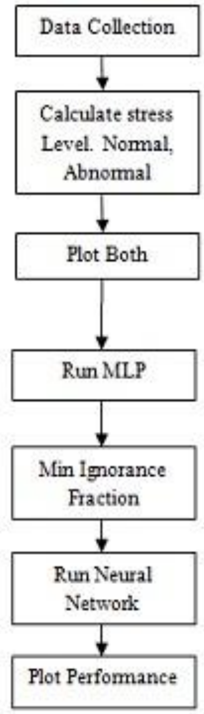


Fig 3: Force Sensing Resistor

5. FLOW CHART



6. METHODOLOGY

The methodology followed for MLP has been briefly described in the following section:

6.1 Data collection from sensors

Data collection was done to have different values of force. FSR i.e. Force sensor resistor is used to collect data from robotic arm joint by applying force with variation.

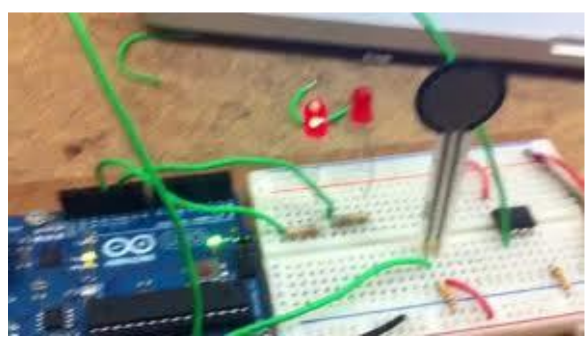


Fig 4: Apparatus

6.2 Calculations

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Calculations are done by obtaining stress levels with the help of FSR in between the robotic arm. These calculations are done by applying different pressure to the FSK. Readings taken for stress are on the scale of 0 to 7. Further the normal and abnormal behavior of the stress being applied on the robotic joint is also plotted for MLP method. Following are screen shots obtained by applying these methods:

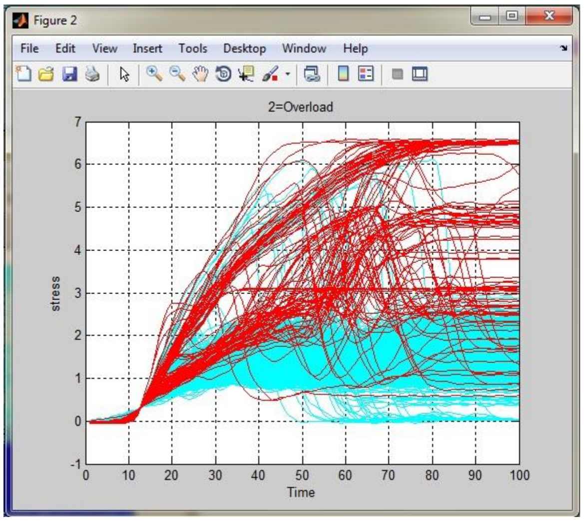

Fig 5: Normal condition with sky blue and overloading with Red shown. MLP

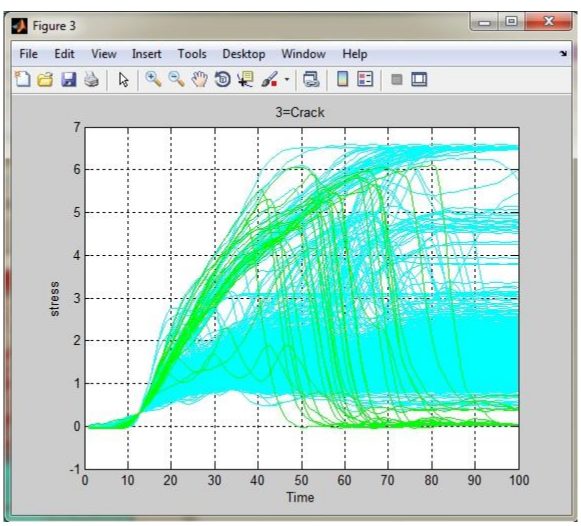

Fig 6: Crack Plot. MLP

6.3 Run MLP

The method is executed i.e. MLP. In MLP after getting the plots for stress in robotic arm, plots are divided into two categories that are overloading and crack. The overloading graph shows the condition in which joint of robotic arm is showing overloading and the other graph shows when the robotic arm joint is going to crack. Further, neural network is applied which is indeed is MLP i.e. Multilayer preceptron. 10-Fold cross validation method is applied to train, validate and test the functioning of the system. Also the system is trained with MLP and results are calculated with accuracy index.

7. FOLD CROSS VALIDATION

A brief introduction to (10) – fold cross validation method is given to illustrate the concept. In 10 fold cross validation method we use to divide the data into k subsets of (approximately) equal size. Then train the net k times, each time leaving out one of the subsets from training, but using only the omitted subset to compute whatever error criterion interests us. In this data is divided into subsets of three by dividing 100% data into training (70%), validation (15%) and testing (15%). Training is the process of providing feedback to the algorithm in order to adjust the predictive power of the classifier(s) it produces. Testing is the process of determining the realistic accuracy of the classifier(s) which were produced by the algorithm. During testing, the classifier(s) are given never-before-seen instances of data to do a final confirmation that the classifier's accuracy is not drastically different from that during training. Validation is (usually) performed after each training step and it is performed in order to help determine if the classifier is being over fitted [8]. The validation step does not provide any feedback to the algorithm in order to adjust the classifier, but it helps determine if over fitting is occurring and it signals when the training should be terminated.

8. RESULTS

After applying the method, different results come into consideration which helps in proposing an accurate stress analysis. It is concluded that MLP is reliable and helps the robotic arm to learn quickly future overloading risks.

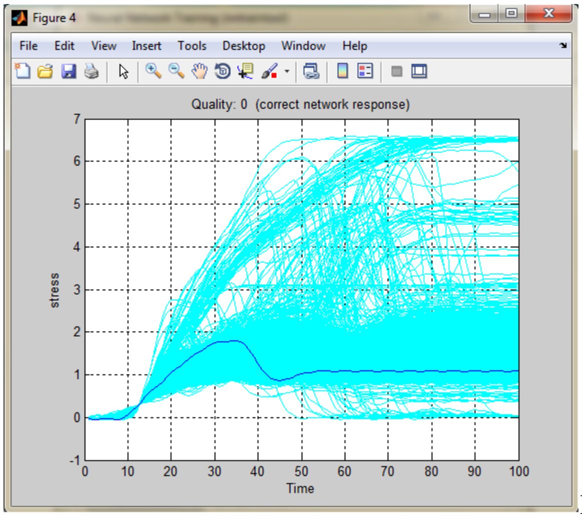

Fig 9: Crack shown due to overloading

Fig 9 shows the value at which crack occurs when robotic arm is working for long time

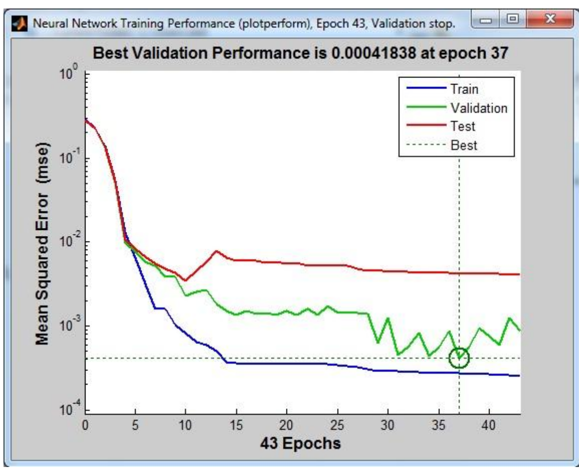

Fig 10: Performance with MLP

Fig 10 shows that with MLP robotic arm manipulator first gets training than validation and goes through training. In MLP the system gets trained after 43 epochs or after 43 iterations and also in this method best validation performance comes at 37th epoch.

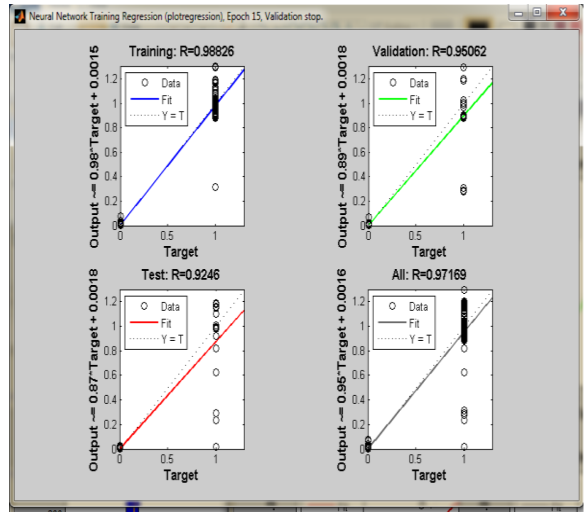

Fig 11: 10-fold cross validation method in MLP

In this graph 10 fold cross validation method is used firstly to train the system, then to validate and in the end testing is done. In this the value of R or regression is 0.97169

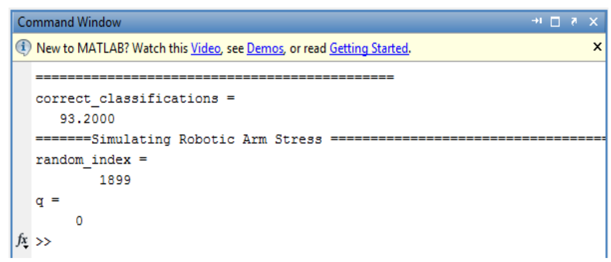

Fig 12: Accuracy of MLP

Fig 12 shows the accuracy of MLP method which comes as 93.20 %. This value of accuracy is more than the previously used MLP methods to find out stress.

9. CONCLUSION

This paper has proposed a method to analyze stress or overloading on robotic arm joint. Method used is MLP. In this, firstly the data is collected and then put to test with MLP method. Method used i.e. MLP trains the system to automatically find out risk of overloading after 43 trainings or epochs and also it is calculated that this method is 93.20% accurate.. Therefore from the results, it is concluded that MLP i.e. multilayer preceptron is an accurate method and also quick method to learn risk management of robotic arm failure due to overstress or overloading.

10. FUTURE WORK

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Methods proposed can be used in exoskeletons, which is an external skeleton used to help handicap people. As a FSR can be programmed with MLP method and joined at the joints of robotic skeleton of exoskeleton. These methods can be used with other heavy commercially available weight lifters.

12. REFERENCES

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