Artificial Neural Networks and Their Use in Process Monitoring and Diagnosis of an Industrial Injection Molding Process

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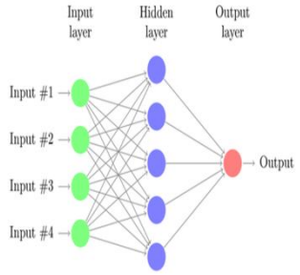
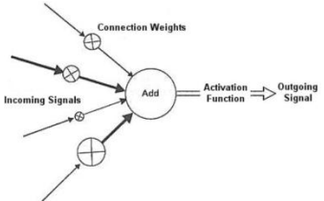
What is an ANN?

- Modeled after biological neural networks found in human brain
- Advanced modeling tools that *learn* while operating and adapt
- Model complex relationships between input and output data or find patterns in data
- Simultaneously infer function being used on data and implement it on next data set



Structure of ANNs

- Synthetic neurons connected by series of weights, one weight per connection between neurons
- Weights and input signal combine with activation function in node to produce output signal
- Weights adapted to achieve desired output signal
- Signal connections can go through hidden layers to increase efficiency of network



ANNs in Injection Molding

- Midwest Molding, Inc., provided annotated process data
- Five variables of importance
  - Fill time
  - Charge time
  - Cycle time
  - Actual cushion
  - Max injection pressure
- All variables related to production with unknown connection weights

EasyNN-Plus Software

- Software used to create artificial neural networks to analyze data
- Potentially predict when a malfunction is imminent
- Import actual process data into software to train network
- Additional data imported to test efficiency of network
- Training method used by software is back-propagation

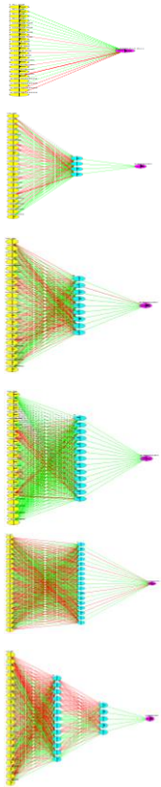
Results

Basic Networks

Artificial Neural Network Type	Number of Nodes				Results				
	Input Layer	Hidden Layer 1	Hidden Layer 2	Output Layer	% Accurate	True Positives	True Negatives	False Positives	False Negatives
Original Data 1	5	0	0	1	86.0	239	7	0	40
Original Data 2	5	3	0	1	99.0	279	4	3	0
Original Data 3	5	8	0	1	91.3	254	7	0	25
Pattern One 1	10	0	0	1	100.0	136	7	0	0
Pattern One 2	10	3	0	1	100.0	136	7	0	0
Pattern Two	15	0	0	1	100.0	88	7	0	0
Pattern Three 1	20	0	0	1	91.5	64	1	6	0
Pattern Three 2	20	4	0	1	91.5	64	1	6	0
Pattern Three 3	20	9	0	1	95.8	64	4	3	0
Pattern Three 4	20	13	0	1	90.1	64	0	7	0
Pattern Three 5	20	17	0	1	56.3	33	7	0	31
Pattern Three 6	20	13	5	1	94.4	64	3	4	0

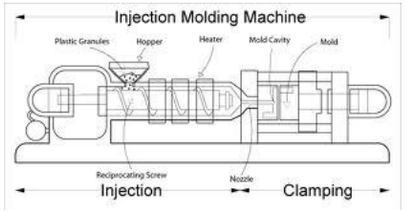
Prediction Networks

Artificial Neural Network Type	Number of Nodes				Results				
	Input Layer	Hidden Layer 1	Hidden Layer 2	Output Layer	% Accurate	True Positives	True Negatives	False Positives	False Negatives
Pattern Four 1	15	0	0	1	49.3	31	4	3	33
Pattern Four 2	15	4	0	1	90.1	64	0	7	0
Pattern Four 3	15	8	0	1	90.1	63	1	6	1
Pattern Four 4	15	13	0	1	83.1	59	0	7	5
Pattern Four 5	15	8	5	1	90.1	64	0	7	0



Process Monitoring and Diagnosis

- Use recorded process variables to determine if process is behaving normally or abnormally
- Artificial neural networks can analyze an event and predict the probability of a similar one happening again
- ANN can find connections between seemingly unrelated variables
- ANN used for fault diagnosis by storing data of past faults
  - Used because of size and complexity of process data to be captured and stored
  - No explanation capabilities



Injection Molding

- Industrial process using molten thermoplastic material
- Used to produce plastic parts in many fields
- Screw-type ram forces plastic through heated cylinder into mold cavity
- Plastic cools and hardens into shape of cavity
- Part is ejected from machine and process begins again