Use of a Neural Network Algorithm in Multiple-Sensor Weigh-In-Motion

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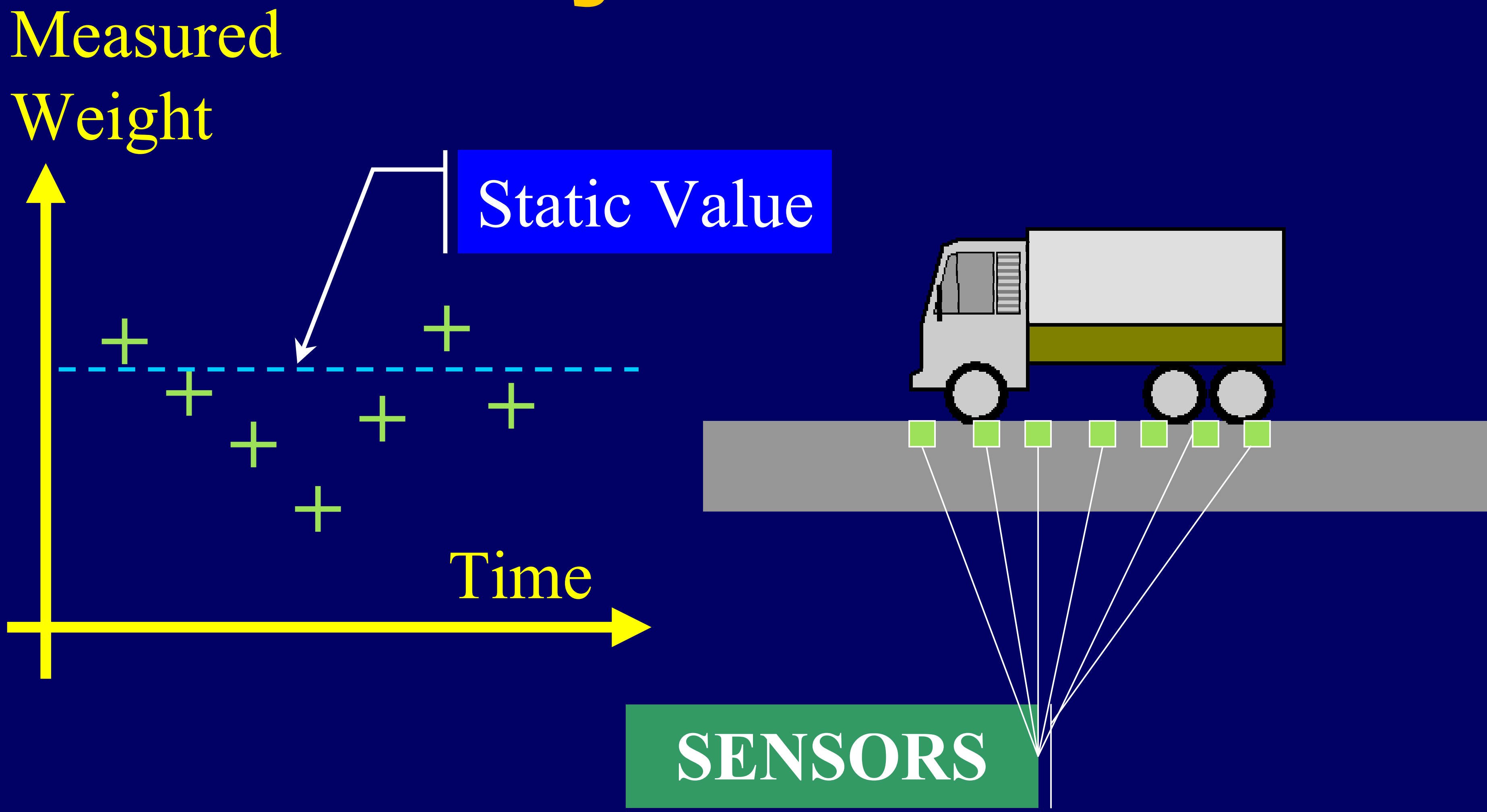
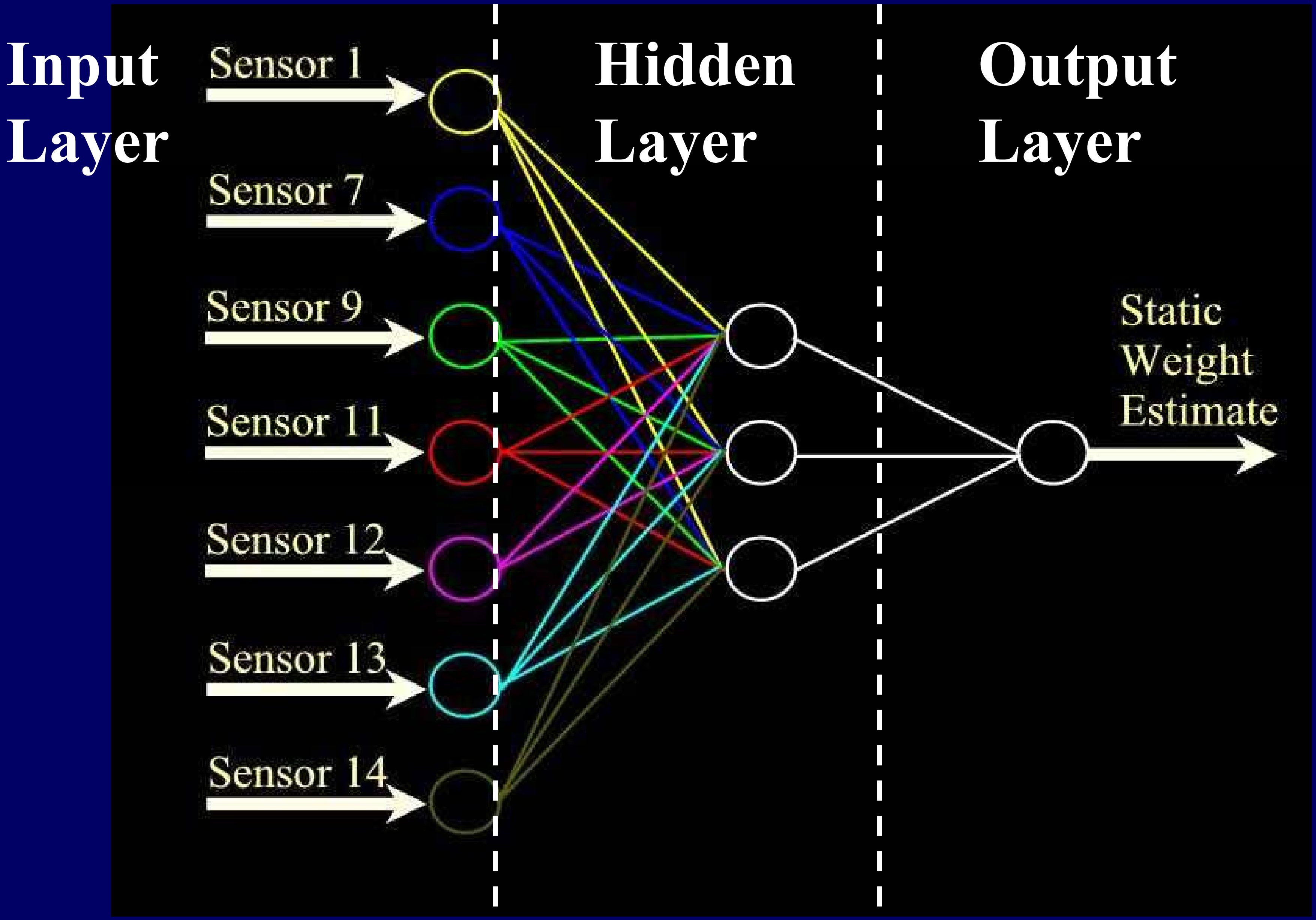
Multiple-Sensor WIM Systems

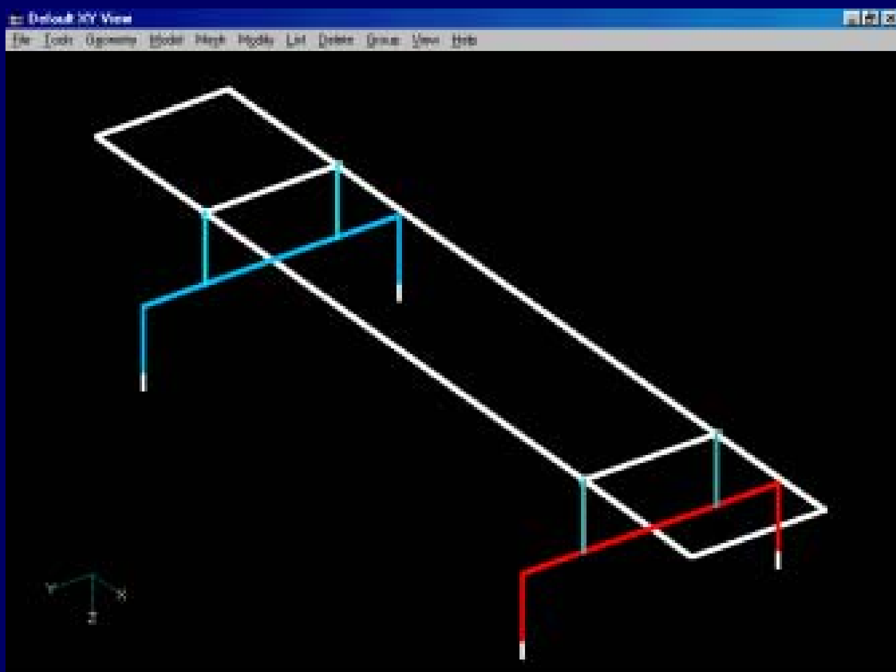


Neural Network Algorithm

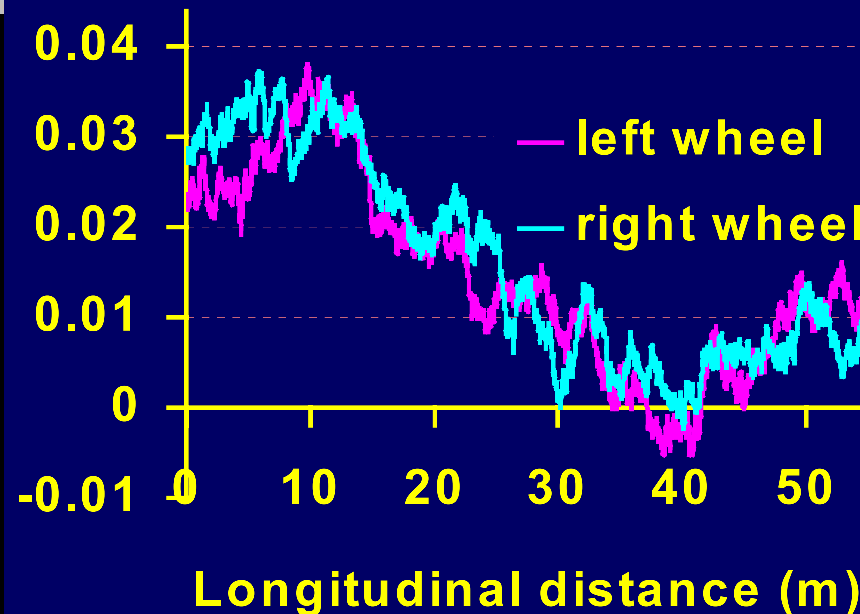


Simulations

- 400 runs of a 3-D rigid two-axle truck model.



- Class B Road Profile



- Dynamic Wheel Forces calculated at 7 sensor locations.

Accuracy and Stability

	Neural Network Output trained with			Average
	Set 1	Set 2	Set 3	
Mean Error	1.59	1.61	1.69	3.39
Stand. Dev.	0.57	0.57	0.57	1.48
Delta min.	3.0	3.0	3.1	7.0

Influence of a Faulty Sensor on Neural Network

	Biased train. Set		Unbiased Set	
Trained	Set 1-0.3	Set 1-1.2	Set 1	Set 1
Tested	Set 4-0.3	Set 4-1.2	Set 4-0.3	Set 4-1.2
Mean	1.78	1.44	2.82	1.25
Stand.	0.41	0.62	0.44	0.60
Del.Min	2.8	3.0	3.9	2.7

Influence of Noise on Neural Network Estimate

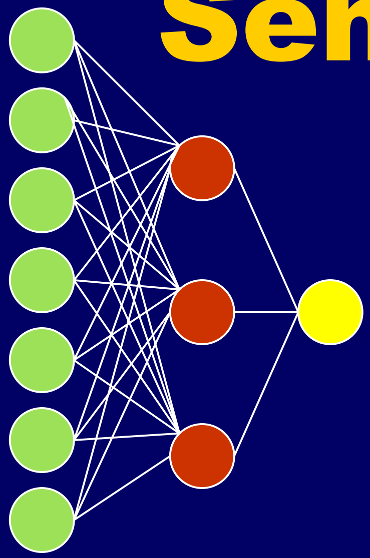
	Number of Noisy Sensors		
	1	3	7
Mean Error	1.59	1.54	1.60
Standard Dev.	0.57	0.76	0.90
Delta min.	3.0	3.4	3.9

Testing with Field Data

- Data from 11 two-axle trucks, 21 four-axle trucks and 42 five-axle trucks (Trappes, France).

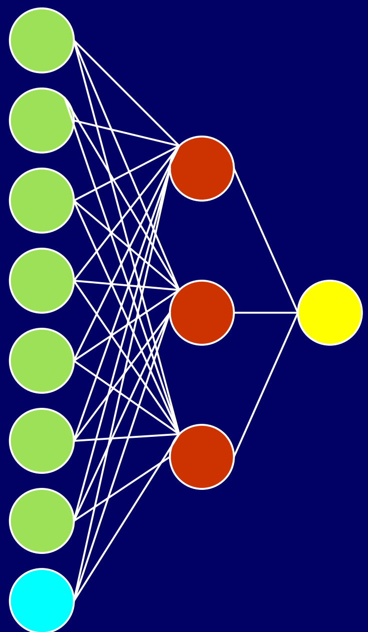
- From a large 24-sensor array, the most accurate sub-array of **7-sensors** is selected to train the Network.

Accuracy using as Input Sensor Weights Only



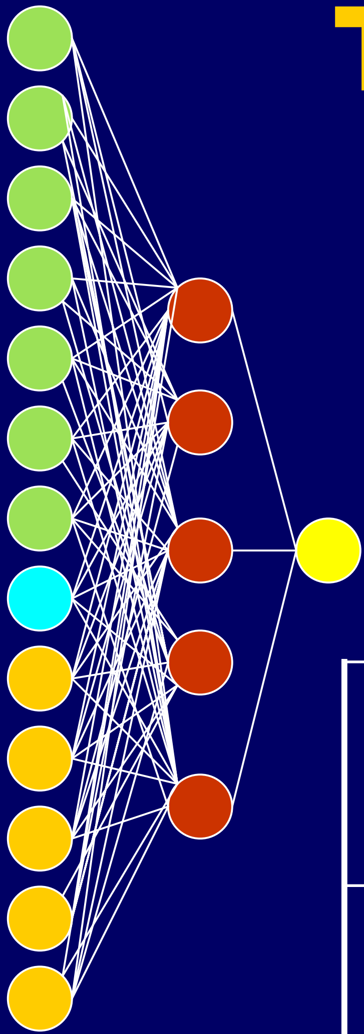
	Neural Network		Average Method	
	Delta min.	Class	Delta min.	Class
GVW	5.8	B+(7)	7.5	B+(7)
Single Axles	9.1	B+(7)	9.2	B+(7)
All Axles	11.4	B(10)	11.7	B(10)

Accuracy using Speed as an Input



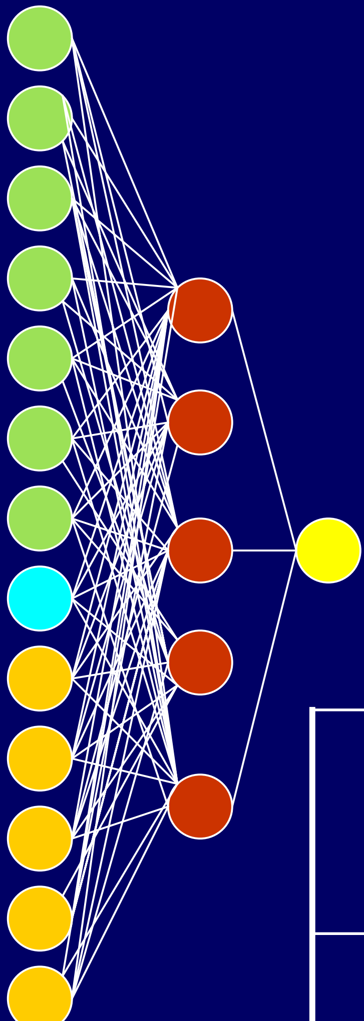
	Neural Network		Average Method	
	Delta min.	Class	Delta min.	Class
GVW	5.9	B+(7)	7.5	B+(7)
Single Axles	8.6	B+(7)	9.2	B+(7)
All Axles	12.6	B(10)	11.7	B(10)

Accuracy using Type of Truck as an Input



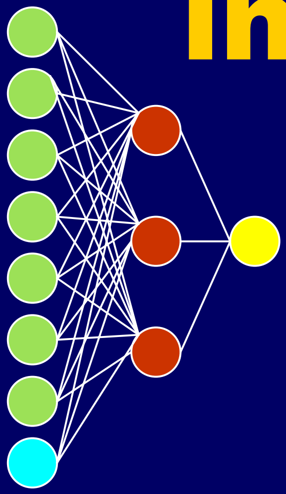
	Neural Network		Average Method	
	Delta min.	Class	Delta min.	Class
Single Axles	9.7	B+(7)	11	B(10)
All Axles	9.3	B+(7)	8.1	B+(7)

Accuracy using Rank of Axle as an Input



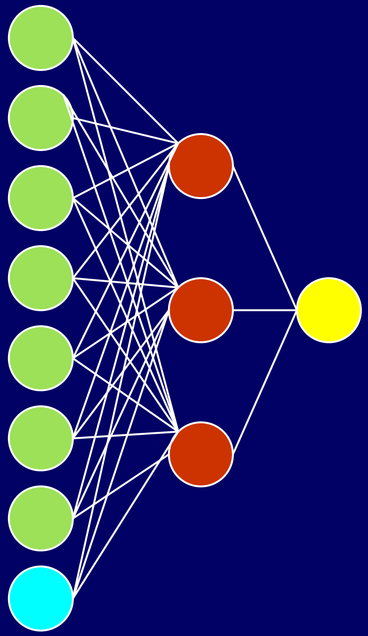
	Neural Network		Average Method	
	Delta min.	Class	Delta min.	Class
Single Axles	**7.3**	A(5)	11.9	B(10)
All Axles	**12.6**	B(10)	12.8	B(10)

Accuracy Separating Data into Weight Divisions



	Neural Network		Average Method	
	Delta min.	Class	Delta min.	Class
Heavy (> 6 tonne)	**8**	A(5)	9.6	B+(7)
Medium (From 4 to 6 t)	**7.4**	A(5)	8.5	B+(7)
Light (< 4 t)	27	D(25)	**24.1**	D+(20)

Accuracy using Calibrated and Uncalibrated Data



	Uncalibrated Data		Calibrated Data	
	Delta min.	Class	Delta min.	Class
GVW	5.7	B+(7)	5.9	B+(7)
Single Axles	8.7	B+(7)	8.6	B+(7)

Conclusions

- Simulated Traffic Data indicated that the Neural Network remained **Stable** and **Largely Unaffected by Bias** or **Noise** in the sensor readings.
- From Field Data, Neural Networks were generally **More Accurate than the Average Method**. Accuracy can be further improved by considering as an Input, not only Sensor Weigths, but also **Speed, Rank of Axle, Type of Truck and Separating Axle Weights into Weight Divisions**.