Artificial neural network ensembles applied to missile aerodynamic coefficient prediction and wind tunnel data storage

These slides were presented at the Arnold Engineering Development Complex (AEDC), the US Air Force's largest wind tunnel facility. On the right are some sample slides and a summary of the topics represented.

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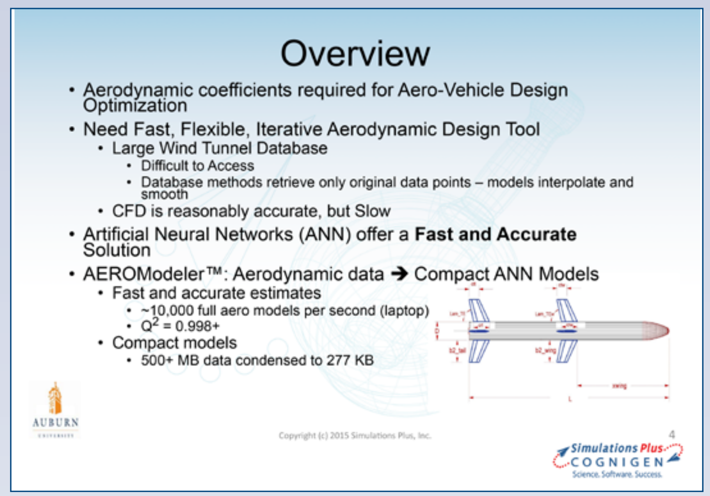
Cover illustration courtesy of AEDC.

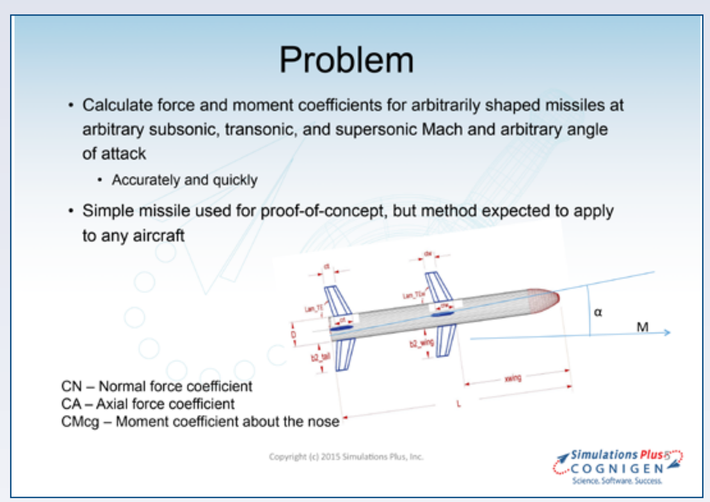
Using Surrogate Models for Data Compression

The presentation starts with an overview of the goal. Surrogate models have been used to model the properties of aerodynamic surfaces. The models yield excellent interpolation results (calculating intermediate results between known data points) and extrapolation results (calculating results outside of, but close to, the trained data space).

As a result, the performance of the aerodynamic surface is encapsulated in a very compact model. The same result can be accomplished when used for data compression—a large quantity of data is summarized by a very accurate, trained model.



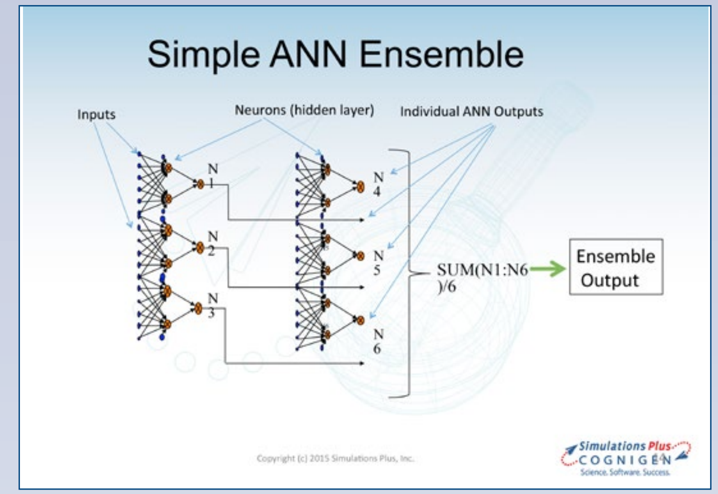
Slide 4. Sets the stage, to show how 500+ MB of wind tunnel data can be compressed to 277 KB with high fidelity and minimal loss of precision.



Slide 5. A brief summary of the problem. The goal was to use simulated wind tunnel test data to train an ANNE to calculate force coefficients for any arbitrarily-shaped missile. The missiles in the data set represented a wide variety of configurations and Mach number.

Detailed Introduction to Surrogate Modeling with Neural Network

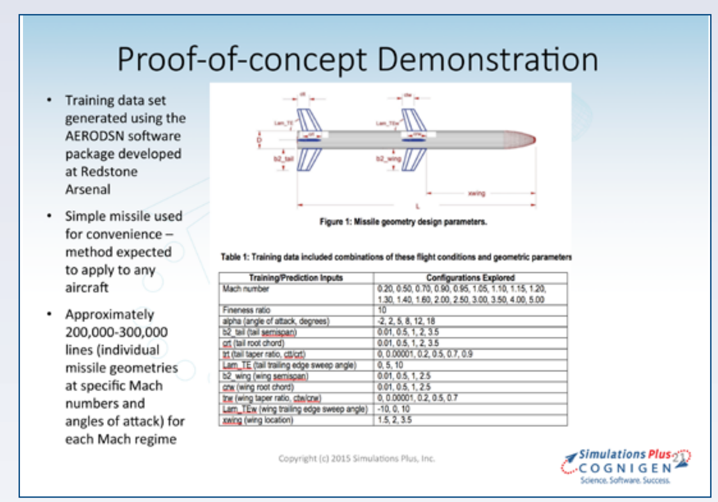
The presentation includes a strong introduction to modeling with neural nets—how data is prepared, how neural networks and ensembles of neural networks function, and how to avoid overtraining.



Slide 14. This diagram shows the architecture of our ANN Ensembles. In this example, the best six networks trained are used in the calculation of the ensemble output.

Demonstrating the Solution

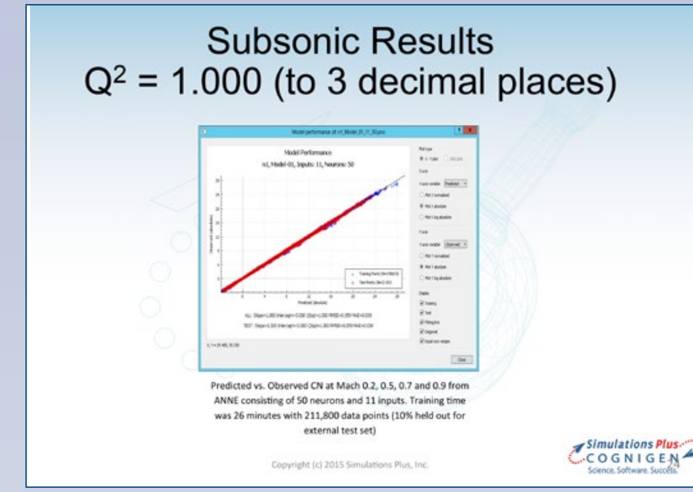
The surrogate model solution is demonstrated and results are shown for the subsonic, transonic and supersonic regimes, showing that the neural network-based surrogate model encodes aerodynamic data with high fidelity and minimal loss.



Training/Prediction Inputs	Configurations Explored
Mach number	0.20, 0.50, 0.70, 0.90, 0.95, 1.05, 1.10, 1.15, 1.20, 1.30, 1.40, 1.60, 2.00, 2.50, 3.00, 3.50, 4.00, 5.00
Fineness ratio	10
alpha (angle of attack, degrees)	-2, 2, 5, 8, 12, 18
b2_tail (tail semispan)	0.01, 0.5, 1, 2, 3.5
crt (tail root chord)	0.01, 0.5, 1, 2, 3.5
trt (tail taper ratio, ctt/crt)	0, 0.00001, 0.2, 0.5, 0.7, 0.9
Lam_TE (tail trailing edge sweep angle)	0, 5, 10
b2_wing (wing semispan)	0.01, 0.5, 1, 2.5
crw (wing root chord)	0.01, 0.5, 1, 2.5
trw (wing taper ratio, ctw/crw)	0, 0.00001, 0.2, 0.5, 0.7
Lam_TEw (wing trailing edge sweep angle)	-10, 0, 10
xwing (wing location)	1.5, 2, 3.5

Slide 21. Using generated data, we were able to produce a proof-of-concept experiment to demonstrate the abilities of our ANNE package, namely the success in predictions.

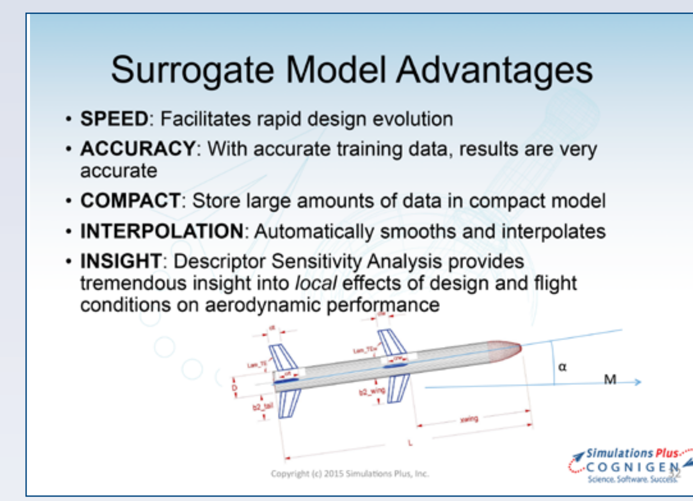
Demonstrating the Solution continued



Slide 24. A sample of the results from the subsonic data set. Subsonic, transonic, and supersonic regimes are modeled.

Concluding slides

The presentation concludes with a summary of the benefits of using surrogate modeling as a method of compressing wind tunnel data with high compression, high fidelity, minimal loss of precision, and extremely fast access.



Slide 32. Summarizes the advantages of surrogate modeling and AEROModeler. Large quantities of wind tunnel data have been generated over the years – models can provide compact storage and rapid/accurate retrieval.

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