Empirical System Identification (ESID) and Optimal Control of Lattice Assisted Nuclear Reaction (LANR) Devices

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14th International Conference on CMNS (LANR)
August 14, 2008
Materials and Optical Measurements

CONCLUSIONS

- Use of Empirical System Identification (ESID), as in flight-test data reduction, or as in Input/Output (I/O) measurement of **macroscopic** *electromechanical* engineering systems or *chemical* engineering systems, ***may*** enable optimization of Lattice Assisted Nuclear Reaction (LANR) energy generation reactors by means of **identification & manipulation** of **Hidden State Variables** in connection with **State Space** Control Theory.
- **IF** ESID also works on **microphysical** systems then:
- Swartz's Optimal Operating Point (**OOP**) with a 3 dB gain can be improved to an **Optimal Operating Path** (**OOPth**) with a **14 dB gain**
- Dardik's **SuperWave** input with a 6 dB gain can be improved to a **HyperWave** input with a **28 dB gain**.

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- At ICCF-1, Bass proposed using ESID technology to discover Hidden State-Vectors and their governing Dynamics in order to design feedback control systems for fusion reactors. The goal was to manipulate the hidden variables to optimize reactor performance.
- At ICCF-7, Swartz introduced the concept of Optimal Operating Point (OOP) as the set of conditions under which the Power Gain from Input electrical energy to Output thermal energy is optimized.

- Bass, R.W. “On Empirical System ID, Possible External Electromagnetic/ Electronuclear Stimulation/Actuation and Automatic Feedback Control of Cold Fusion,” Proceedings ICCF-1 (1990).
- Swartz, M, "Optimal Operating Point Characteristics of Nickel Light Water Experiments," Proceedings of ICCF-7 (1998).

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- The hypothesis which we investigated was whether these technologies may have improved efficacy when their complementary approaches are appropriately combined.
- For these experiments, data was obtained from an active Phusor™-type LANR device producing excess energy, as demonstrated by redundant calorimetry and heat flow measurements.
- The data was initially investigated by ESID technology using a hidden state-vector dimension n = 6, and matrices (A,B,C) of sizes respectively 6-by-6, 6-by-1, 1-by-6 based upon a Ho-Kalman-Leverrier algorithm (Bass 2006).

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- This was found to be limited for this LANR work. The identified n = 6 system had poles too near to the boundary of the unit-circle in the complex-frequency plane |z| = 1, where the Leverrier algorithm is known to be numerically fragile. Therefore the ESID approach was repeated using the more statistically-sophisticated Canonical Variate Analysis (CVA), using the more numerically robust linear “subspace” approach (Wallace Larimore, Adaptics Inc., ADAPTx).

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- When this was applied, with the optimal state-vector dimension n = 3, the analysis demonstrated an excess Power Gain of circa 175%, in good agreement with the other independent methods which examined the specimen during the preliminary analysis. On reconstruction, the analysis had a rather stunning 92.2% accurate Prediction by ADAPTx (Figure).

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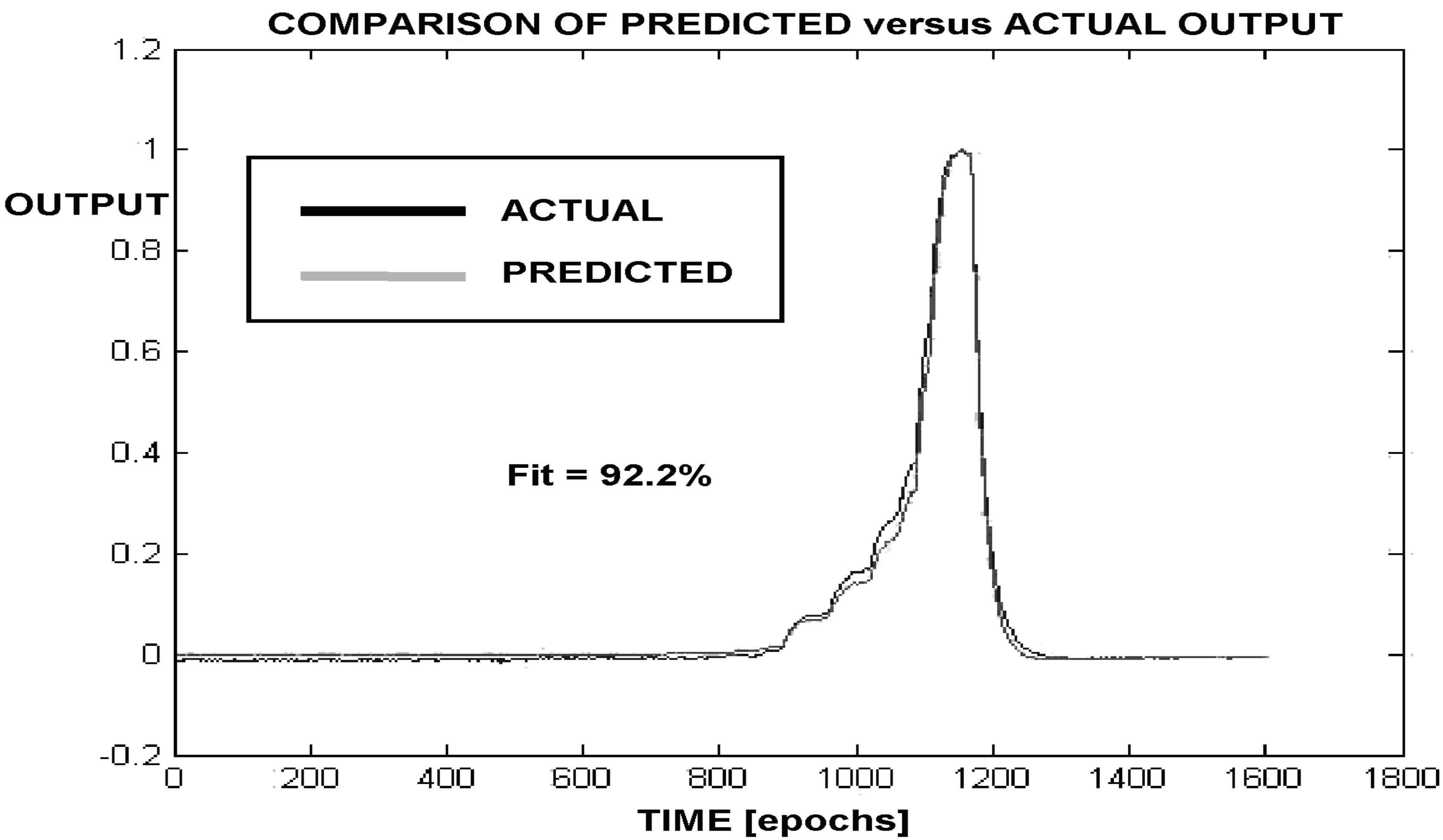

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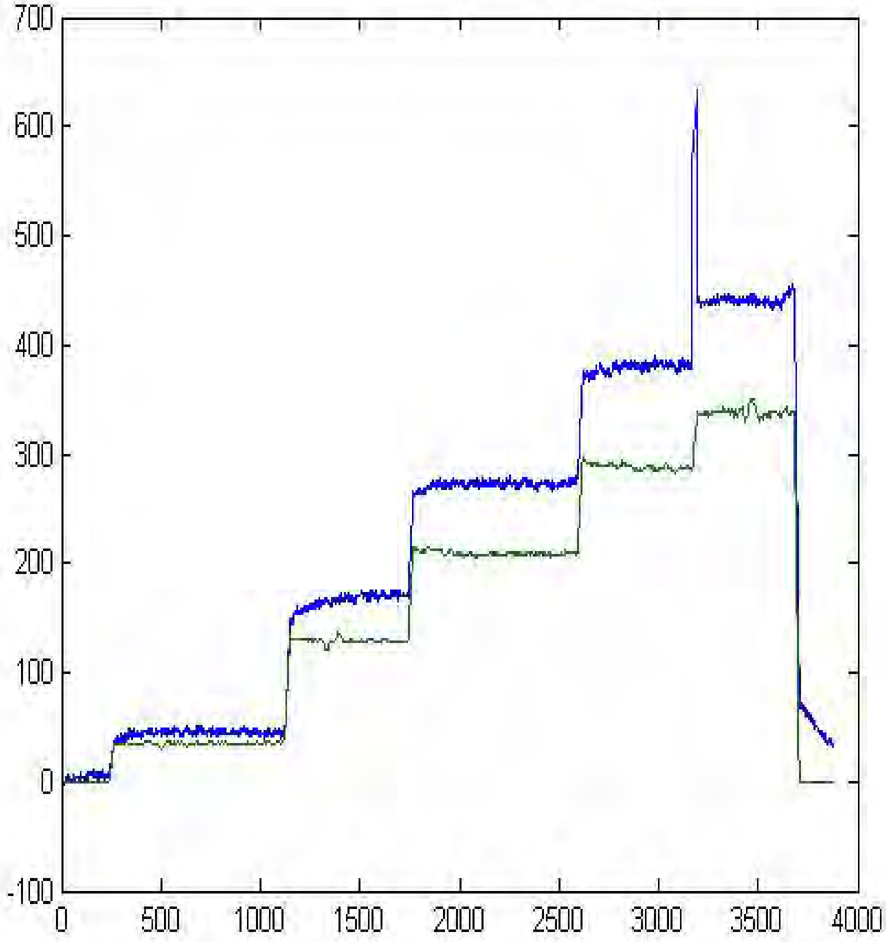
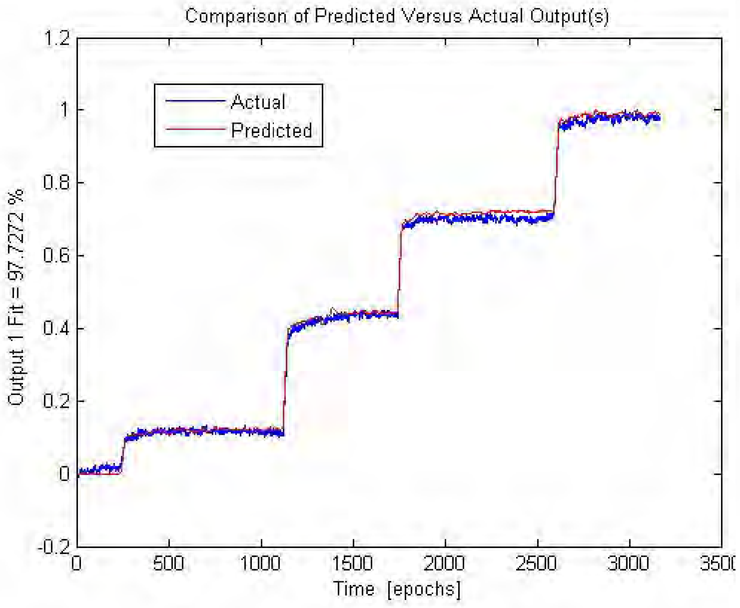
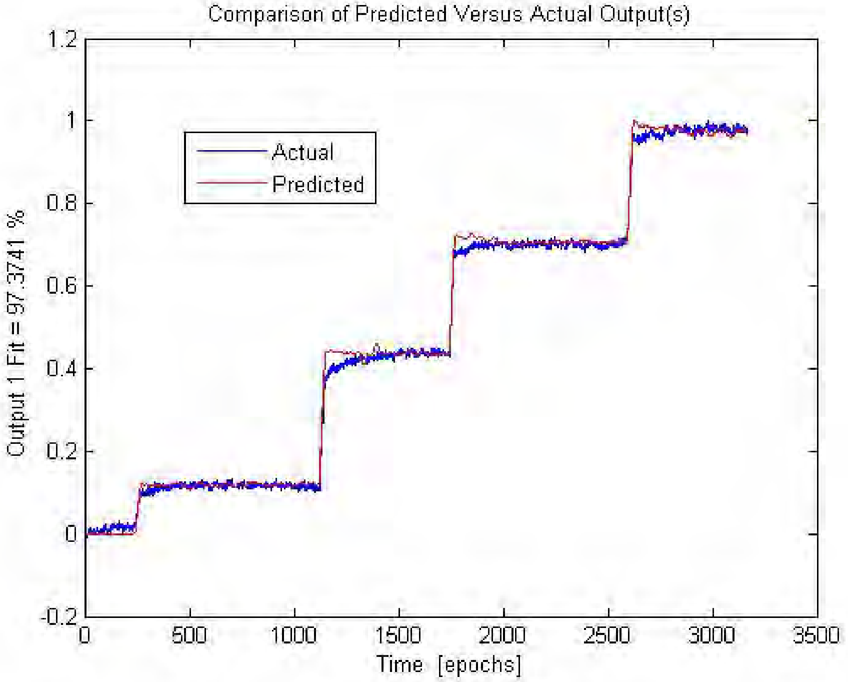
Result of 5-dimensional state-vector and associated (A,B,C,D) used to predict the Output Power from the Input Power on the LHS of the Optimal Operating Point (OOP) segment results in 97% accuracy for the "ascending" initial segment of the data, and likewise a similarly excellent [93% accuracy] n = 5 model for the "descending" part of the data from the Phusor^{TM} LANR device, which had an Output, ~33% larger than the Input.



The "first cut" at the ID of the LHS gave an optimal state-vector dimension of n = 30.
But the RHS got an excellent result with n = 5.
Use of "Balanced Order Reduction" reduced n from n = 30 to n = 5, which degraded the excellence of the fit only in the 3rd decimal place, from 97.7% to 97.3%.





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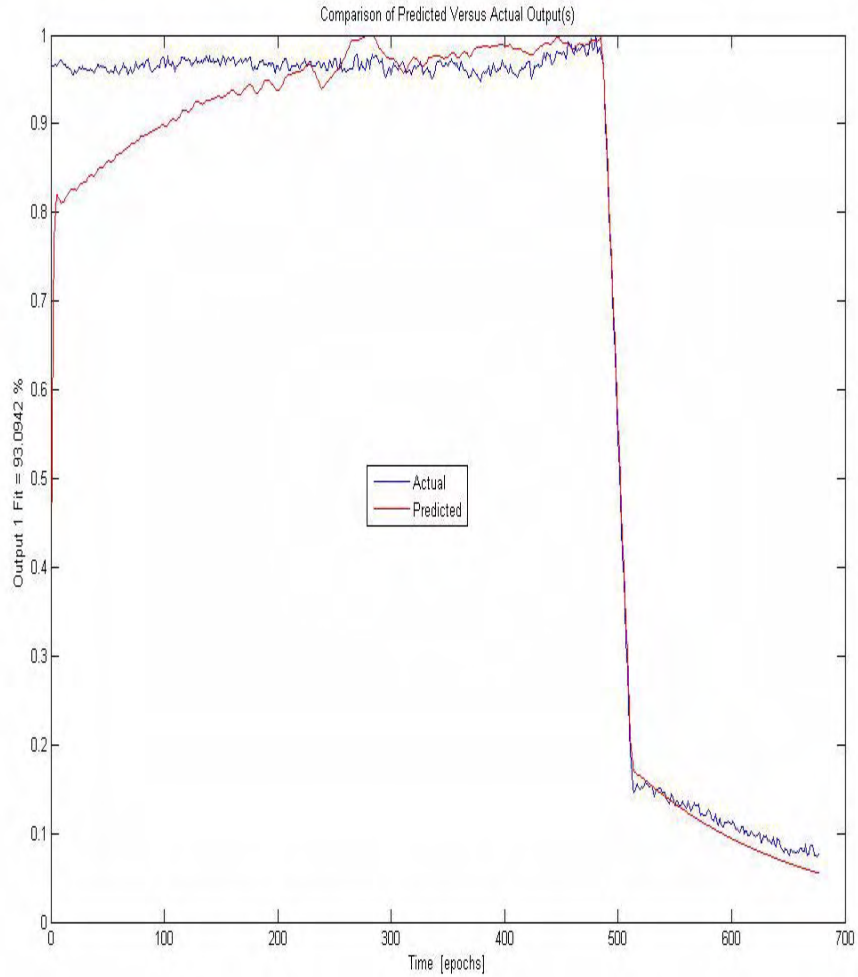
After converting the n = 5 "ascending" and "descending" models to the same coordinate system, “initial” & "final" equilibrium state-vectors to the left & right of the OOP segment, were found, using “ending”: & "beginning" equilibrium state-vectors at the termination of the “ascending segment & initiation o the "descending" segment on the RHS of the OOP manifold.
Both of these states predict that the best achievable gain may be circa 33% more Output Power than Input Power when the <u>associated</u> dynamics is used.



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- There are two implications.
- **First**, ESID technology may offer advanced OOP control, where the "predicted" output is derived based upon the empirically-identified mathematical model and subsequent numerical calculations based upon applying the numerical values of the actual input to the model.

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- Our preliminary studies appear to confirm the effectiveness of this principle.
- **Second**, presently, OOP is found by manual experimentation and proprietary automated techniques. These may be augmented by a Kalman Observer to estimate the state-vector x(k) in real time, and thereby enable the implementation of a State-Feedback Control Law to seek out the OOP automatically, and subsequently maintain the system operating as near to its OOP as is possible.

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Moreover, using the algebraic Controllability theory of Kalman, very important new results have been uncovered.

By transfer of both sets of (A,B,C,D) matrices to the same coordinate system, and computation of the mean value of the 5-dimensional State Vectors on the LHS & the RHS of the JET Phusor LANR "sweet spot," the putative derived possible power gain might increase by a factor of up to 12 if one used these state-variables in real time, using advanced optimal control theory, such as Kalman's LQR theory, to drive the system toward that particular optimal operating point (OOP) state. Bass' prediction is a possible Output Power gain of more than 14 dB improvement, versus the 3 dB gain which resulted by using OOP technology.

Acknowledgments

The authors thank JET Energy and Innoventek for their support.