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PATTERN RECOGNITION AT LAWRENCE LIVERMORE LABORATORY*

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We at LLL recognize many possible uses of pattern recognition techniques for solving complex scientific problems. Similar to the Laboratory's approach to nuclear weapons R&D, pattern recognition methods are used to develop semi-empirical models describing experimental phenomena. Our general pattern recognition computer code[1] (RECOG) was orginally developed to solve materials problems. Recently the same code has been used to study a variety of problems. Today pattern recognition methods, complimented by many modern data analysis methods, are used in our chemical modeling effort. In addition to studying materials problems, we are involved in unraveling complex kinetic processes and constructing analytic models (semiempirical) for describing decomposition, detonation, aging, etc.

There have been a number of significant pattern recognition studies in the materials area. Probably most impressive was our solution of the high explosive mechanical properties problem. Our analysis of the chemical concentration led to a change in manufacturing specifications. This change has resulted in a higher grade high explosive and has saved the Nation's nuclear weapons program tens to hundreds of thousands of dollars. Another important study involved beryllium parts which were cracking during welding or assembly. Our analysis of the characterization data indicated trace impurity levels were strongly correlated with poor quality. Again specifications were changed and parts produced under

the new specifications have improved properties. In both these studies, pattern recognition methods lead to a solution of the problem and also a better understanding of the product and its production. In the high explosive case, further analysis of the data led to the discovery of an erroneous analytical chemistry method which was used to determine the concentration of one of the constituents. Increased levels of impurities in the beryllium were traced to a faulty waste reprocessing plant.

Pattern recognition techniques are often used to discover synergistic effects encountered in compatibility (aging) testing. For example, we recently carried out a study to determine the cause of the corrosion in a detonator. Because of the urgency for results, we took an experimental approach; the controllable parameters for many of the components were systematically varied, the detonator was then artifically aged (elevated temperature and increased levels of various radiation), and the corrosion was measured. Pattern recognition techniques were used to discover a very subtle interaction between the dye of a plastic component and the high explosive. The chemistry of this interaction was further studied in the laboratory and today we have an accurate analytic model which describes the corrosion process. In all probability this interaction would have been discovered by conventional techniques; however, our analysis of the data required only a few minutes and this timeliness cannot be overemphasized.

Another interesting area of our pattern recognition studies involved relating chemical and physical measurements to performance. In these cases we are not solving materials problems but rather trying to understand the "chemistry and physics" of the material so we can hopefully design a better material. For example, we are currently studying chemical and mechanical

measurements made on the high explosive PETN in the hope of understanding the relationship among the measurements and the performance property (detonation velocity).

There have been many spin-offs from our material studies; higher quality materials, new and better performing materials, and, of course, the general code RECOG has been applied to many other problems. The codes were used in our acid-base study[2], the cancer screening study[3], and for modeling analytical experiments[4]. The Laboratory is currently developing an improved uranium prospecting program (1 million dollars/year) which will rely very heavily on our pattern recognition techniques. We expect these techniques to be of even greater Laboratory use in the future.

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