System Theory

A system is a device which accepts inputs and then operates on them to produce outputs. Many disciplines are involved in developing system theories. In order to discuss the recent advances in this field, mathematicians, engineers, and physicists convened at an international symposium at the Polytechnic Institute of Brooklyn, New York (20–22 April).

The emergence of system theory from recent developments in the analysis of engineering systems, and the relation between this theory and classical mathematical studies were described by R. F. Drenick (Brooklyn Polytechnic Institute). Although engineering may pose problems whose solutions are most taxing to applied mathematics, it seems that engineering has progressed to some conceptual innovations and theories whose importance goes well beyond all possible practical applications. Studies of optimal engineering designs for communications and control systems spurred the growth of optimal control theory, filtering theory, and information theory. The present realm of system theory is roughly defined by the concepts and methods common to these theories, but its future development may be influenced by their intriguing differences.

Probability theory and random processes are essential ingredients in filtering theory, but meaningful and challenging control problems, as surveyed by L. W. Neustadt (University of Southern California), can be posed in purely deterministic terms. Recent developments in filtering theory and applications of it to significant engineering systems were presented by R. E. Kalman (Stanford), D. E. Johansen (Sylvania), and S. L. Fagin (Sperry Gyroscope Co.). The applications included computer data processing for orbit determination and adjustment of inertial navigations systems.

A probabilistic approach to systems containing uncertainties lead naturally to problems of system identification and construction of stochastic models. W. L. Root (University of Michigan) discussed the use of integral operators for representing time-invariant and time-varying systems in terms of their observable inputs and outputs. Model simplifications resulting from information-theoretic approximations were described by N. M. Abramson (University of California). An alternative approach to system uncertainties was introduced by L. A. Zadeh (University of California) by using "fuzzy-system" concepts which are related to multivalued logical systems.

Stability ideas possess all the traits of system theoretic concepts. Classical dynamical theory models were summarized by L. A. MacColl (Brooklyn Polytechnic Institute), and were brought to bear on recent stability results through recurrence principles by J. Auslander (Yale). Extensions from classical stability models have been inspired by optimal control theory. As an example of these new approaches, E. O. Roxin (University of Buenos Aires) presented results on stability properties which apply for sets of possible inputs. Finally, as reported by H. J. Kushner (Brown), some results are available for the even more complex stochastic systems.

Stability theory also acts as a provocative contrasting link between dynamical theory and discrete-state machine theory. Despite the similarities of the systems studied by these theories, stability does not seem to be a major consideration in discrete-state studies. Recent work in the latter area, as described by M. Davis (Yeshiva) and C. C. Elgot (I.B.M.), seeems to have no counterpart in the former area.

Properties of causal systems, those whose outputs do not anticipate their inputs, are most fundamental to system theory. D. L. Hanson (University of Missouri) presented recent results related to the Wold decomposition problem; this problem asks if two random processes, with given statistics, can be the input and output, respectively, of a causal system. The results classify systems and processes in a manner which emphasizes distinctions between continuous and discrete-state systems. In related studies, R. Goodman (M.I.T.) has derived causal system results for equations of evolution which arise in relativistic quantum mechanics. He finds that equations describing massless particles generate nondeterministic systems, while equations describing particles of nonzero mass generate deterministic systems.

The engineering heritage of theory was portrayed by J. G. Truxal (Brooklyn Polytechnic Institute), who also indicated several current and challenging practical problems which may be solved eventually with the aid of future theoretical results. A plea for well-engineered research was delivered by R. Bellman (Rand Corp.), who called for the matching of researchers to problems for which they are suited and the choosing of meaningful problems rather than easy ones or those which are merely extensions of results of dubious value.

The symposium also included papers on economic and biological systems. Complete proceedings will be published in the fall of 1965.

This symposium, the fifteenth in an annual series, was organized by the Polytechnic Institute of Brooklyn in cooperation with the Information Theory, Circuit Theory, and Automatic Control Professional Groups of the Institute of Electrical and Electronics Engineers and the Society for Industrial and Applied Mathematics. The symposium was co-sponsored by the Air Force Office of Scientific Research, the Office of Naval Research, and the U.S. Army Research Office.

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Forthcoming Events

September

1–3. American **Geophysical** Union, 5th western natl. meeting, Dallas, Tex. (AGU, 1145 19th St., NW, Washington, D.C.)

1–3. **Metallurgists**, 4th annual conf., Ottawa, Ont. (Canadian Inst. of Mining and Metallurgy, 906 Drummond Bldg., 117 St. Catherine St. W., Montreal, Que.)

1–3. Biomedical Aspects of **Shock and Vibration Technology**, symp., Denver, Colo. (E. R. Wilson, 5745 S. Huron St., Littleton, Colo. 80120)

1–4. **Aeronautics**, 6th European congr., Munich, Germany. (Wissenschaftliche Gesellschaft für Luft und Raumfahrt, Martinstr. 40–42, 5 Cologne)

1–4. International Assoc. of **Gerontology**, European Clinical section, 4th congr., San Remo, Italy. (A. Zilli, Viale Morgagin 85, Florence, Italy)

1–4. **Immunological Methods**, symp., Chantilly, France. (R. H. Regamey, Intern. Assoc. of Microbiological Societies, Inst. d'Hygiene, 1200 Geneva, Switzerland)

1–4. Society of General **Physiologists**, 20th annual, Marine Biological Laboratory, Woods Hole, Mass. (R. Milkman, Dept. of Zoology, Syracuse Univ., Syracuse, N.Y. 13210)

1–5. **Regional Science** Assoc., 5th European congr., Warsaw, Poland. (H. Wood, Dept. of Regional Science, Univ. of Pennsylvania, Philadelphia 19104)

1–8. **History of Pharmacy**, intern. congr., London, England. (A. L. Short, Pharmaceutical Soc. of Great Britain, 17 Bloomsbury Sq., London W.C.1)

1–9. **Physiological Sciences**, 23rd intern. congr., Tokyo, Japan. (G. Kato, Dept. of Physiology, Keio Univ. School of Medicine, Shinjuku-ku, Tokyo)

1–14. **Cosmical Gas Dynamics**, 5th