new, but more importantly because Haberer's ideal typology does not seem to work out very well. Haberer sees Oppenheimer, in his arrogance and isolation, as a Cartesian scientist, yet even from the material presented in the book he could fit equally well into a Baconian mold. For a start, his contribution to the Manhattan Project was that not of the lonely genius but of the team manager, and, significantly, this work was never to receive that accolade of scientific distinction, a Nobel prize. The Bomb itself, a technological achievement, was supremely a Baconian rather than a Cartesian development (here let us register a protest at the persistent Americanization of the Bomb, which at times in Haberer's account seems only paralleled by the Russianization of, say, cybernetics or television).

Oppenheimer emerged during this period as one of that élite group of 200 to 300 top U.S. scientists working in the upper echelons of government who form perhaps the nearest approximation to a New Atlantis to be found today in the Western world. For Oppenheimer, as for Bacon, there is an assumption that in the main the needs of state, science, and humanity coincide. Thus Oppenheimer found it possible to accept the dual and incompatible function of operating a system designed simultaneously to develop bigger and better bombs and to control them. For Oppenheimer, as for the scientific élite of the New Atlantis, the Bomb had transcended politics—it had become a scientific, and therefore consensual, affair. There are ironic parallels in the careers of Oppenheimer and Bacon, both court favorites, both displaced, both retiring from public life into the writing of graceful essays, unhappily removed, to be sure, from the levels of power both enjoyed manipulating, but thereafter left unpersecuted. And by way of epitaph, when a court favorite falls, who cares?

Such comments are prompted by Haberer's decision to juxtapose the Oppenheimer case with the rich study of the German science community. Unlike the historical analysis he presents for Germany, he treats Oppenheimer's career in terms of its own ups and downs rather than in relation to the crisis of physics, so that we are led to ask, Why should the author be surprised that there was no greater reaction in the scientific community to so minor an event as the denial of a bomb-maker's security clearance? Though there was a consensus about the legitimacy of working on the Manhattan Project until Hiroshima, working on the H-bomb after 1945 became morally and politically repugnant to many physicists. Unlike the German scientists, they resisted by not working on it, and by attacking with informed and skeptical criticism the AEC that Oppenheimer continued to serve; they opposed the militarization of nuclear physics, and helped public opinion force controls on testing.

By concentrating on the reaction of the scientific community to the Oppenheimer affair rather than to the crisis for science and humanity, which receives only elliptical treatment, as for example in the reference to Norbert Wiener's open letter disassociating himself from military science, Haberer's account, though very well presented, does less than justice to its theme. It also means that he abandons the debate about responsibility at the point where the past conflicts of the 1930's, '40's, and '50's impose on the present ones of the '60's and '70's. Without reference to the plethora of new organizations in the United States—and elsewhere—concerned with the theme of responsibility and democracy in science, with the burgeoning military-industrial-scientific complex, secret research in the university, the abuse of science in Vietnam, and the response of the scientific community, Haberer has perhaps avoided the central challenge to his models of science and its politics.

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Pictorial Information

Picture Processing by Computer. AZRIEL ROSENFELD. Academic Press, New York, 1969. x + 198 pp., illus. $11.50. Computer Science and Applied Mathematics.

This is an important and useful exposition of the state of the art of picture processing, presented largely in terms of available methods of established validity. This is not to imply that Rosenfeld has constructed a mere formulary. On the contrary, we have here the systematic presentation of a set of picture processing procedures, preceded by clear and yet concise chapters on sampling and encoding. In general the discussion of processing methods pays due attention to the theoretical basis, the varying modes of implementation, and significant examples of application of each method. Outstanding in this regard are the three chapters on position-invariant operations, which in a sense are the kernel of the book.

One might expect the author (who is, after all, a mathematician) to employ a certain degree of formalism in a presentation such as this. The expectation is borne out, but Rosenfeld uses his mathematics judiciously. He spares the nonmathematician reader unnecessary pyrotechnical exhibitions on the one hand, and on the other the almost equally frequent pain caused by cryptic brevity in detailing a proof. As is promised implicitly in the preface, one needs only a modicum of mathematical maturity to follow the argument.

The novice in picture processing would do well to give this seriously written work a careful cover-to-cover reading. He will be amply repaid, if only by the resultant ability to use the book subsequently as a reference text or handbook. This is particularly important since the author has insightfully selected and integrated the scattered mathematical, computer science, linguistic, and optical references which constitute the literature of picture processing. This collection will go a long way in helping to prevent the repeated reinventions of established technics which occur so frequently in young and multidisciplinary fields.

Workers at all levels of sophistication in this field should occasionally pause and consider that (for the foreseeable future at least) there are no general rules about which method or methods apply to a given picture or class of pictures. Transformations are not necessarily reversible, nor are their sequences necessarily commutative. Moreover, the methodology required to process a picture in one context, that is, for a particular purpose, is not necessarily the same as the technic that must be used to characterize the same image for a different one.

More experienced workers will find numerous sources of stimulation beginning with the very first chapter. For example, consideration of the implications of Rosenfeld's rather restricted (but not unreasonable) definition of a picture function results in the realization that a microscopic image is for many reasons not strictly a picture in his sense. The direction for generalization to such images is indicated but, understandably, is not fully explicated.

In contrast, the term "processing" is construed far more broadly by Rosenfeld than it would be by most problem-oriented workers in the field. Processing to him includes coding, enhancement, segmentation, and other such operations as well as recognition or analysis. Lastly, the word "computer" in the title is actually equivalent to "algorithmic," so that the title might be paraphrased as "useful and interesting algorithmic transformations of two-dimensional optical density arrays," but this would not attract as wide an audience as the book deserves.

Thus far I have dealt with Rosenfeld's main concern—what might be termed picture information of the first kind, or *inherent* information. This information, expressible as relations among the various possible subsets of resolution elements and their respective gray values which together constitute the picture, must be distinguished from picture information of the second kind. The latter, which might be termed *added* information, is that information which the human brings to the picture in fulfilling the task of detecting, analyzing, describing, or classifying images or objects within images. The added information simply cannot be evoked or isolated no matter how the picture or image is processed or transformed. It does provide a structure upon which parts of the inherent information may be organized. Indeed, such structures would seem to be required even before systematic rather than pragmatic information reduction can take place.

Systematic treatment of added information is not easy. The added information is relatively inaccessible, residing as it does in the intellect of the picture analyst and elicitable usually only by linguistic informant technics. However, creation of useful structures of added information becomes increasingly feasible as the picture class is increasingly constrained, or, in other words, as problem orientation plays an increasingly large role. Even here formal picture descriptions which are generative, in the same sense as linguistic grammars, remain (except in relatively trivial cases) theoretically possible but unrealized objects.

Rosenfeld's final chapter ("Picture description and picture languages") is a brief characterization of the research on the use of added information for primarily picture analysis. Its brevity is regrettable but understandable. However, if picture processing is ever to transcend mere pragmatic employment of mathematical tools (no matter how elegant) much more attention will have to be paid to the use of formal models of classes of images. This may mean that picture processing may make greatest progress in those problem-oriented areas where the user is willing to defer immediate results—until powerful logical structures can be developed to drive, as it were, the picture analyses.

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Significant Measures

Statistical Power Analysis for the Behavioral Sciences. JACOB COHEN. Academic Press, New York, 1969. xvi + 416 pp. $13.50.

"A lady declares that by tasting a cup of tea made with milk she can discriminate whether the milk or the tea infusion was first added to the cup. We will consider the problem of designing an experiment by means of which this assertion can be tested." Thus Sir Ronald Fisher begins his chapter on hypothesis testing in *The Design of Experiments* (ed. 4, Edinburgh, 1947). Suppose the claim is tested by presenting to the lady two cups of tea, one made by each method, and asking her to indicate which is which, this trial being repeated 15 times. Presumably the lady will get some pairs correct even if she is just guessing. Therefore, to establish her claim, she must do substantially better than chance. In the language of statistical hypothesis testing, the hypothesis that she is guessing is called the null hypothesis; and we assume that the probability of any set of outcomes can be correctly calculated on the basis of this hypothesis. To evaluate the lady's actual performance, we calculate the probability (under the null hypothesis) that a chance mechanism could have done as well as or better than she did. If this probability is small, the experiment is said to be statistically significant. The value of this probability, called its significance level, is often used to summarize how convincingly the data disprove the null hypothesis. The idea is that, since a result as good as or better than that observed would only rarely occur by chance, a causal mechanism is the more reasonable explanation.

Assume that our lady has some ability to discriminate correctly between the cups, without being perfect. We know that her score will vary from one set of 15 trials to another. We now ask, if her true (long-run) batting average is known, what is the probability that a single experiment, of 15 trials, will yield a result significant at a specified significance level? This probability is called the power of the test, and answering this question for a variety of experimental situations is the purpose of the book under review. For example, Cohen's tables show that if her true average is 70 percent, only about half the time would a 15-trial experiment be significant at the 5-percent level of significance. On the other hand, if her true average were 80 percent, then about 84 out of 100 such experiments would meet the criterion.

In general, assuming the model and the calculations to be correct, the factors determining the power of a test are the significance level, the sample size, the inherent variability of the data, and the actual, though unknown, size of the effect the experimenter is trying to demonstrate. Without losing generality, Cohen measures the size of the effect in terms of the data's variability.

For each statistical test considered, Cohen presents two tables. One gives the power as a function of level of significance, effect size, and sample size; the other gives the sample size required to obtain a given power as a function of effect size and level of significance. (Since this latter quantity can be easily obtained by scanning the columns of the first table, the second is largely only a convenience.) The book covers most parametric tests likely to be found in an introductory or intermediate textbook, including approximations for the power of the test for interaction in the analysis of variance. Except for the sign test, no nonparametric or sequential tests are covered.

Choosing an appropriate effect size to use in assessing the power of a test is often difficult, since the true value is, of course, not known. Cohen works hard on this problem, using both examples and a generalized concept of small, medium, and large effects, which will be both understandable and useful to many social scientists. While a rigorous handling of a prior distribution is beyond the scope of the book, the idea of taking a weighted average of the power against several alternatives would