This Week's Citation Classic

Shepp L A & Logan B F. The Fourier reconstruction of a head section.
IEEE Trans. Nucl. Sci. NS-21:21-43, 1974.
[Bell Laboratories, Murray Hill, NJ]

The contributions of this paper were: (1) making explicit a direct algorithm for reconstruction of a density from its measured line integrals; (2) a general framework for choosing convolution filters; (3) a specific example of such a filter; and (4) a method of simulation used to distinguish artifacts due to undersampling from those due to errors in data acquisition, based on an anthropomorphic head phantom. [The *SCI*® indicates that this paper has been cited in over 170 publications since 1974.]

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"I became interested in computed tomography (CT) after attending an early, inspiring, and brilliant presentation of the exciting and revolutionary first commercial CT scanner by its inventor, Godfrey Hounsfield, at Columbia-Presbyterian Hospital in 1972. I asked him whether or not he had considered using a formula-based algorithm rather than the iterative one he presented, because I thought that the former would work better. He hesitated momentarily, perhaps not expecting a technical question from the white-coated audience, and said that they were indeed looking into the possibility. I knew then what I would be doing for the next months. Later I was told that an alternative noniterative algorithm had already been developed in his lab[1] but did not receive the attention it deserved, (perhaps) because the method of simulation was not used to distinguish data artifacts from algorithmic artifacts.

"Undoubtedly, the main reason for its frequent citation is that it was a timely paper in a highly relevant and interdisciplinary field which had *already* revolutionized radiology. X-ray vision captivated mathematicians, radiologists, physicists, computer scientists, and statisticians alike, each of whom correctly felt that their own field had a contributing role to play. Some of the companies openly advertised the use of the approach of our paper which further attracted interest. Amusingly, it later became clear that this advertising was mainly done because the companies thought their use of a published result lessened the chances of an infringement of patent suit.

"Since our algorithm was not completely new in a sense, and since our framework for choosing convolution filters and method of simulation are contributions which are not easily citable without a lot of words, many citers who wanted to acknowledge a debt to us stated that our example of a filter was our main contribution. Some even gave mathematical arguments to prove that the Shepp-Logan filter was the best possible filter, and companies were advertising their use of our filter. This pained me, and not only because the filter was actually Ben Logan's idea. We both never felt, as even a casual reading of the paper shows, that there was anything wonderful about this filter. Instead, we felt that our insight into the CT problem came down to choosing some filter, and our giving a general basis or insight for choosing the filter—namely, ($\hat{\mu}(\omega) \approx |\omega|$ for small $|\omega|$)—was our real contribution to reconstruction algorithms. The actual choice of the filter should be made taking into account each machine's characteristics: X-ray spot size, collimation, etc.

"My paper[2] with J.B. Kruskal describes in detail a side benefit of using an anthropomorphic phantom. (Incidentally, that paper won a Lester R. Ford prize for the best expository mathematics paper for 1979.) Namely, it was realized that the large space between brain and skull visible on CT scans was really an artifact of sampling since it appeared on the iterative reconstruction of the mathematical phantom but was not present on the original phantom. This quickly became widely known in the radiological community and attracted further interest to our work.

"Many people enjoyed using the anthropomorphic technique which was made simpler by the fact that the paper contained our simple Fortran reconstruction program, which was included at the fortunate suggestion of Z.H. Cho. This extra measure of explicitness helped to attract serious readers, I believe."

1. **Lemay C.** Personal communication.
2. **Shepp L A & Kruskal J B.** Computerized tomography: the new medical X-ray technology. *Amer. Math. Mon.* 85:420-39, 1978.