

NOTES ON “AN INTERDISCILINARY INTRODUCTION TO IMAGE PROCESSING”

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ABSTRACT

A 2012 MIT Press book by Steven L. Tanimoto focuses on types of images that are markedly different from the examples found in other texts on similar topics. In addition to introducing basic image programming methods, it encourages exploration of the artistic and aesthetic aspects of image synthesis and image transformations.

KEYWORDS: Image transformation, image synthesis, PixelMath, Python, artistic creativity

In “An interdisciplinary introduction to image processing” (MIT Press 2012), Steven Tanimoto explores the intersection of computer science with image processing, graphics, fine arts, and perceptual psychology. Deviating from the traditional pedagogic perspective on image processing, he concentrates on image transformation and synthesis rather than analysis. The book is clearly the work of an enthusiastic and knowledgeable professor who wanted a text to engage first or second year students in the somewhat esoteric topics that excite him. Other professors grooved in fine arts and computer graphics may enjoy teaching from this text. It is also appropriate for self-study and perhaps even for pre-college home-schooling.



The proposed pedagogy is built around PixelMath2012, which can be downloaded from Tanimoto’s website. PixelMath is a multi-platform graphic interface to an extensive set of image processing programs. It can display an arbitrary number of windows of arbitrary size and location and fill them with images from files or with the results of transformations applied to these images. After choosing one or two source windows and a destination window, the PixelMath engine applies transformations specified at the pixel level by built-in functions, by Python programs, or by Java Runtime Environment scripts. All of these functionalities are well integrated. The student progresses from creating new pictures with the push of a button, to applying selected PixelMath formulas, to writing complex Python programs (or at least reading the author’s), to creating new GUIs with Java/Swing.

In contrast to MS Paint and Adobe Photoshop, PixelMath allows computing the position and RGB values of a destination pixel from the values of a specified set of pixels in the same or in one or more other images. An image window can contain a mask, a template, or even complex 2-D Fourier Transform coefficients. This architecture allows arbitrary point, neighborhood, and geometric transformations, including diffusion and blending.



The interdisciplinary aspects consist mainly of examples based on both classical and hyper-modern art work, brief explanations of esthetic considerations, and illustrations of unusual graphic art forms. The latter include a variety of anamorphic images from da Vinci to computer anamorphosis, mosaics tiled with miniature images, fractals, autostereograms, catadioptric photographs, high-dynamic range image rendition, morphing, professional photo “enhancement,” and artful illustrations of mathematical bibelots like Eratosthenes’ Sieve. A downside is the many figures of distorted versions of La Gioconda that few readers will consider an improvement on Leonardo’s original.



The book introduces some mathematical tools like functions, modulo arithmetic, complex numbers, vectors, gradients, Laplacians, Gaussians, and random number generators. It does not use any calculus. Several chapters are devoted to Python. The coding examples range from one or two lines with a paragraph or two of explanation, to reprints of programs of several hundred lines. These long programs, possibly originating in the author’s research, have good naming conventions and adequate comments but little or no explanation of their logical development. They contain advanced Python constructs, often including functional (*lambda*) notation, and culminate in the exploration of the Python code underlying PixelMath itself. Sections on data structures, programming techniques and software engineering serve as an introduction to advanced computer science courses.

The chapter on computational photography explains current autofocus technology and describes some special types of cameras. It also discusses the separation of direct and indirect illumination,

combining photos to increase spatial extent or dynamic range, and image repair. It does not, however, mention the non-linear intensity response of sensors and the customary quantification of dynamic range in units of optical density. Some of the code for increasing dynamic range is obfuscated by the expedient of using complex arithmetic to double the eight-bit image representation to decrease round-off error.

Copious figures – mostly generated by PixelMath – illustrate the image manipulation algorithms. Thirty-two figures are also reproduced as color plates, but the student will gain more from watching the dynamic image streams produced by the downloadable programs and, hopefully, from carrying out the well thought out exercises. The appendixes on PixelMath formulas and Python commands are excellent, as is the Glossary. There is a comprehensive Index. Some references are provided in each chapter (except Chapter 17, titled *Image Processing!*). In spite of the attractive hardcopy format, glossy plates, careful editing and rich web supplements, the book is priced far below most college texts.



The last chapter demonstrates the construction of an educational PixelGraphics game based on Concentration. Concentration requires opponents to memorize the location of face-down cards as they try to pick matching pairs (like red sevens or black Queens). In the first version of the PixelMath game, a matching pair is an image and its transform. In the second version, a matching pair is the transformed image and the formula used for the transformation. The program is divided into major components suitable for group projects: Game, Board, and Control. Students may actually enjoy playing it!

An Interdisciplinary Introduction ... will likely earn the reader's affection and gain a number of turned down corners that mark sections to be revisited. The clear but low-key exposition reveals the deepening relationships between art, computer science, and the web, and offers percipient insights into the new role of the computer artist. Some of the images and the mild jokes will elicit smiles. Regardless of the reader's motivation, education and age, he or she will be richer for the takeaways.