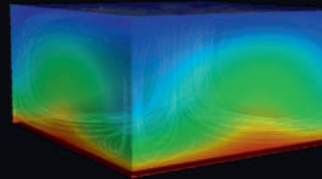
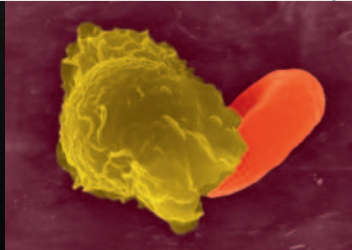




Brad Eric Hollister
Alex Pang



A Concise Introduction to Scientific Visualization

Past, Present, and Future

 Springer

A Concise Introduction to Scientific Visualization

Brad Eric Hollister · Alex Pang

A Concise Introduction to Scientific Visualization

Past, Present, and Future

 Springer

Brad Eric Hollister
Department of Computer Science
California State University,
Dominguez Hills
Carson, CA, USA

Alex Pang
Department of Computer Science
University of California, Santa Cruz
Santa Cruz, CA, USA

ISBN 978-3-030-86418-7

ISBN 978-3-030-86419-4 (eBook)

<https://doi.org/10.1007/978-3-030-86419-4>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Main Image/Drawing:

- The water mechanism/Leonardo Da Vinci: © wowinside/[stock.adobe.com](https://www.adobe.com)

Image Bar from left to right:

- Simian immunodeficiency virus, 3D model. © Donald Bliss (Nlm), Sriram Subramaniam/National Cancer Institute/Science Photo Library
- RBC, SEM: © DENNIS KUNKEL MICROSCOPY/Science Photo Library
- Rayleigh Bernard Convection simulation: (CC BY-SA 3.0): [https://commons.wikimedia.org/wiki/File:RayleighBernardConvection.png/http://wiki.palabos.org/community:gallery:rb_3d/Author: LBMethod.org/jonas](https://commons.wikimedia.org/wiki/File:RayleighBernardConvection.png/http://wiki.palabos.org/community:gallery:rb_3d/Author:LBMethod.org/jonas)

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Much of our cortex is dedicated to processing visual information, and it imposes upon mental models a physical intuition. While there are exceptions in modern science when our visual nature leads to artifact, for the vast number of problems our ability to visualize the natural world has elevated human understanding to its current level. Using imagery, we are able to see the unseeable, and thus further knowledge.

This treatise will outline scientific visualization. While there is an established related field of information visualization, we mostly address visualization for scientific purposes. Despite modern buzzwords like “data science” and computer graphics in popular media, the general public (and even some academics) remain unfamiliar with scientific visualization. But, anyone capable of mental pictures, often instinctively uses visualization to solve problems they encounter. If their solutions model the natural world, or produce useful abstractions from it, then this type of problem-solving is considered scientific visualization.

Scientific visualization is not an isolated area of research. While today, visualization is primarily computer-generated, visualization in science stretches back to a time well before computers! That said, we do not consider problems in the broader discipline of visualization that are not scientific. Nor do we consider areas of study such as realism in art. When illustration relates to scientific visualization, it is discussed to convey context.

The first two chapters cover the role of geometry in natural science and scientific visualization. A link is drawn between Euclid and the work of da Vinci (and others) of the Renaissance period. Then, the kinematics of celestial motion is presented in connection with later methods for shape and curvature description. Starting with chapter three, we describe Faraday’s insight into invisible electromagnetic fields. Faraday was known to have had his great revelation through visualization of the phenomena. As another case study, Lawrence Bragg, a scientist known to possess an early aptitude for spatial problems, contributed to molecular visualization and the first direct experimental structural determination of matter. Computers still had not been invented yet during this era of scientific visualization, but that was soon to change. In the last two chapters, modern scientific visualization starts to take form. We see how early computer use was directed exclusively at problems of science.

However, not until the latter part of the twentieth century, did the computer become sophisticated enough to draw interactive imagery.

Carson, USA
Santa Cruz, USA

Brad Eric Hollister
Alex Pang

Contents

Early Visual Models	1
Illustration and Analysis	21
Scientific Visualization in the Nineteenth Century	39
A Convergence with Computer Science	57
Recent Developments	79
The Future	95
Index	103