

Architectural Rendering With 3dsmax And Vray

Increase the photorealism of your 3d visualizations with enhanced toolsets of V-ray in 3ds Max. Full-color, step-by-step tutorials about techniques involved in creating photorealistic renders for interior/exterior scenes. Each tutorial includes a 3d project scene to guide you through, production and post-production. The production chapter shows how to create shaders, fine-tune textures and set up a day/night lighting rig. You will be rendering high-res images with render elements included for the final stage of post-production. The book also includes tips about, pre-production, camera settings, verified views, material editors, shaders, 3ds max scripts, and much more! Key Features This book deals with real world scenes and delivers up to date design direction. This book has professional supporting files ready for the reader to open and explore. This book highlights the processes of making your own content that not only gives images your personal touch, but also through the online content that will be made available for this title. Includes some coverage of VRay. Focuses in depth on separate issues surrounding interior, exterior and product design, which vary wildly.

Create high-quality photorealistic renders of architectural visualizations using 3ds Max and Vray with the project-based tutorials in this book. Learn how to combine lighting and rendering options to end-up with the most realistic final renders possible at a professional level. The tutorials in this book are filled with beautiful full-color images and they teach you how to light both interiors and exteriors and daytime and nighttime scenes. Learn how to save time without sacrificing the quality of your final renders with tips and tricks on rendering with Vray - the most accurate rendering application for 3ds Max. The companion CD includes all the project files that you need to recreate each of the projects presented within the book.

An architecture portfolio designed by Alex Hogrefe describing 4 original projects with a focus on unique representational techniques and styles.

This book is lavishly illustrated with step-by-step tutorials and it is filled with useful tips & tricks throughout as well as theories and analyses of each technique implemented. Learn how to produce consistent "jaw dropping" 3D images in three simple steps: Pre-Production, Production and Post-Production. This book provides: * In-depth instructions about the process of creating shaders, textures, lighting, fine-tuning key parameters and rendering. * Unique insight into the Pre-Production processes of establishing and meticulously following the art direction while using the best technical approach. * Detailed process of preparing and importing external files; followed by modelling from 2D drawings. * Robust Post-Production techniques to polish your renders. * Project files for VRay and mental ray. * ...and much, much more. * Plus find more information at <http://jamiocardoso-mentalray.blogspot.com/>

A guide for leveraging SketchUp for any project size, type, or style. New construction or renovation. The revised and updated second edition of The SketchUp Workflow for Architecture offers guidelines for taking SketchUp to the next level in order to incorporate it into every phase of the architectural design process. The text walks through each step of the SketchUp process from the early stages of schematic design and model organization for both renovation and new construction projects to final documentation and shows how to maximize the LayOut toolset for drafting and presentations. Written by a noted expert in the field, the text is filled with tips and techniques to access the power of SketchUp and its related suite of tools. The book presents a flexible workflow method that helps to make common design tasks easier and gives users the information needed to incorporate varying degrees of SketchUp into their design process. Filled with best practices for organizing projects and drafting schematics, this resource also includes suggestions for working with LayOut, an underused but valuable component of SketchUp Pro. In addition, tutorial videos compliment the text and clearly demonstrate more advanced methods. This important text: Presents intermediate and advanced techniques for architects who want to use SketchUp in all stages of the design process Includes in-depth explanations on using the LayOut tool set that contains example plans, details, sections, presentations, and other information Updates the first edition to reflect the changes to SketchUp 2018 and the core functionalities, menus, tools, inferences, arc tools, reporting, and much more Written by a SketchUp authorized trainer who has an active online platform and extensive connections within the SketchUp community Contains accompanying tutorial videos that demonstrate some of the more advanced SketchUp tips and tricks Written for professional architects, as well as professionals in interior design and landscape architecture, The SketchUp Workflow for Architecture offers a revised and updated resource for using SketchUp in all aspects of the architectural design process.

Revitalize your architectural visualizations by bringing new levels of realism to them with an enhanced command of the mental ray toolset in 3ds Max. Full-color step-by-step tutorials give you a firm understanding of the processes and techniques needed to create impressive interior and exterior visualizations. You'll learn how to prepare materials, light a daytime interior scene, use mr Physical Sky, and how to save time during complex renders. The companion website includes all of the tutorial files and sample files from the book. Plus find more information at <http://jamiocardoso-mentalray.blogspot.com/>. * Beautiful full-color visualization projects provide step-by-step instruction on valuable techniques and tools * An official Autodesk Techniques co-branded title written by an authoritative expert on visualization * Companion website contains all of the tutorial files from the book

Learn how to perfect your lighting workflow and produce 3D photorealistic images with the in-depth tutorials featured in these pages.

The updated 2020 edition of the popular step-by-step tutorial for Revit Architecture Shortly after its first publication, Autodesk Revit for Architecture: No Experience Required quickly became the market-leading, real-world guide for learning and building with Revit—the powerful and sophisticated Building Information Modeling (BIM) software used by professionals the world over. Fully updated for Revit 2020, this popular, user-friendly book helps you learn the Revit interface, understand the fundamental concepts and features of the software, and design, document, and present a 3D BIM project. A continuous, step-by-step tutorial guides you through every phase of the project: from placing walls, doors, windows, structural elements, dimensions, and text, to generating documentation, advanced detailing, site grading, construction scheduling, material takeoffs, and much more. Updated and revised to include new content, this invaluable guide covers all the fundamental skills every Revit user needs. Whether used as a complete, start-to-finish lesson or as a quick-reference for unfamiliar tasks, this book will help you: Learn each phase of designing, documenting, and presenting a four-story office building using a simple yet engaging continuous tutorial Follow the tutorial sequentially or jump to any chapter by downloading the project files from the Sybex website Use the start-to-finish tutorial project as a reference for your own real-world projects and to develop a powerful Revit skillset Gain thorough knowledge of Revit's essential concepts and features to make the move from 2D drafting to 3D building information modeling Get up to speed with advanced features, including new coverage of advanced walls, families, sites, topography, and more Autodesk Revit 2020 for

Architecture No Experience Required is the go-to guide for both professionals and students seeking to learn Revit's essential functions quickly and effectively, to understand real workplace projects, processes, and workflows, and to set the stage for continuing on to more advanced skills.

Bring new realism to your visualizations with a command of the 3ds Max toolset. Three step-by-step tutorials demonstrate exterior and interior, day and night lighting scenes. You learn the nuts and bolts of importing models from CAD programs, lighting, applying mr shaders and materials, and optimizing your renders. Mental ray is made simple with an accessible description of its tools. This book was written to support the development of art assets and virtual environments for Serious Games and Architectural Visualization. It caters to those who do not have any experience with 3D modeling, texturing and scene building in a real-time virtual environment. This book focuses on utilizing Autodesk's 3DS Max as the 3D modeling tool, Allegorithmic's MapZone as the texture creation tool, and Terathon's C4 Engine as the real-time virtual environment scene builder. Many of the chapters in this book were written independent of one another to allow students to explore, and use their creativity and imagination in creating their own virtual environments.

A tutorial packed with practical examples and screenshots to help you become an expert in architectural visualization using Unity. This book is written for students and professional architects who know how to model buildings in 3D and have a need to turn their design into an interactive model, even if you have never used Unity before. Experience with visualization and programming will be helpful, but is not required to follow along. You will learn all the basics throughout with the help of step-by-step examples. The majority of the examples work fine in any recent version of the Unity software, on Windows or Mac, but occasionally features of the Pro version are required.

The most comprehensive e-book reference on Autodesk 3ds Max 2013! Autodesk 3ds Max is used to create 80 percent of commercially available games and is also a key tool for visual effects artists and graphic designers in film and television. This convenient book covers the 2013 version in expanded detail, including 12 chapter-length quick-start projects and 39 additional chapters not found in the print version. Along with complete references detailing all Primitives, Modifiers, Materials, Maps, and Controllers, it covers advanced topics such as Patches, NURBS, Radiosity, Network Rendering, and MAXScript. It's the perfect resource for both novices and pros. 3ds Max is the tool of choice for game developers as well as visual effects artists and graphic designers in the film and TV industries. This comprehensive e-book includes complete coverage of 3ds Max 2013, and is well suited for beginners and experts alike, as well as for educational markets teaching beginning to advanced courses using 3ds Max. Features a complete reference for all Primitives, Modifiers, Materials, Maps, and Controllers. Covers Patches, NURBS, Radiosity, Network Rendering, MAXScript, and other advanced topics. Includes 12 chapter-length quick-start projects as well as 39 chapters not found in the print version, all packed with time-saving tips and expert advice. Third-party models and bonus tutorials are available on CD and can be obtained by readers by emailing a request to 3dsmax13cd@wiley.com. Autodesk 3ds Max 2013 Bible, Expanded Edition by veteran computer graphics author Kelly Murdock is the comprehensive e-book guide for every 3ds Max user.

Bring new realism to your visualizations with a command of the 3ds Max toolset. Three step-by-step tutorials demonstrate exterior and interior, day and night lighting scenes. You learn the nuts and bolts of importing models from CAD programs, lighting, applying mr shaders and materials, and optimizing your renders. Mental ray is made simple with an accessible description of its tools. * Color reproductions illustrate a wide array of subtle techniques. * mental ray is made easy with accessible demonstrations. * Companion CD contains all of the project files.

Revitalize your architectural visualizations by bringing new levels of realism to them with an enhanced command of the mental ray toolset in 3ds Max. Full-color step-by-step tutorials give you a firm understanding of the processes and techniques needed to create impressive interior and exterior visualizations. You'll learn how to prepare materials, light a daytime interior scene, use mr Physical Sky, and how to save time during complex renders. The companion website includes all of the tutorial files and sample files from the book. Plus find more information at <http://jamiocardoso-mentalray.blogspot.com/>

This book is filled with examples explaining the theoretical concepts behind them. Filled with sample screenshots, diagrams, and final rendered images, this book will help readers develop an understanding of photographic rendering with V-Ray. If you are a SketchUp user who would love to turn your favourite modelling application into a 'virtual photography studio', then this book has been designed and written for you. Existing V-Ray users will also find plenty to enjoy and benefit from in this book. Some basic experience with SketchUp and familiarity with photography will be helpful, but is not mandatory.

3ds Max is the leading 3D modeling, animation, and rendering solution for artists, schools, and production environments. The unique tutorial approach of this book permits readers to learn essential techniques that every 3D artist needs to create CG environments by recreating the earth's elements of earth, air, fire and water. No extra plug-ins are required to perform the exercises. Draper studies the real world and then simulates it with 3ds Max - a unique approach that reflects classical art training. "Deconstructing the Elements" allows artists to re-create natural effects using Autodesk® 3ds Max®. This new edition boasts all new tutorials. All editorial content is updated to be current with the current version of 3ds Max. Inspirational images cover every page as the author shares his professional insight, detailing the how and why of each effect, ensuring the reader a complete understanding of all the processes involved. The companion web site includes all of the tutorials from the previous two editions, only available to purchasers of this 3rd edition - plus all new tutorials of the current edition. It's like getting 3 books in one!

Great guide to the fundamentals of Autodesk 3ds Max 2014 This Autodesk Official Press guide is just what you need to learn the basics of Autodesk 3ds Max 2014 quickly and easily. Through a series of cool projects like designing an alarm clock, animating a thrown knife, or lighting a scene, you'll learn the essentials of modeling, rigging, animating, and rendering using the popular Autodesk 3ds Max 3D animation and effects software. It's a practical, hands-on approach allowing you to constantly reinforce skills as you learn them. Downloadable before-and-after project files let you to compare your work to that of 3ds Max professionals. Even if you already have experience with 3ds Max, this book is a great reference for renewing your skills. And, it will help all users review and prepare for the Autodesk 3ds Max 2014 certification exams. Helps beginners and those migrating from other 3D animation and effects programs get up and

running on Autodesk 3ds Max 2014 Features a realistic, task-based approach, so readers learn via a series of hands-on projects using downloadable files, all backed with ample instruction, explanation, and illustration. Covers modeling, rigging, animating, rendering, skinning, architectural visualization, and more. Written by Autodesk Authorized Authors and is an Autodesk Official Press book. Get firsthand experience with 3ds Max, as well as a good start on preparing for the Autodesk 3ds Max 2014 Certified Professional exam, with Autodesk 3ds Max 2014 Essentials.

Description The Autodesk 3ds Max 2020: A Detailed Guide to Modeling, Texturing, Lighting, and Rendering book is perfect for both beginners and intermediate users of 3ds Max and for those moving from other software to 3ds Max. This brilliant guide takes you step-by-step through the whole process of modeling, texturing, UV mapping, lighting, and rendering. You will learn important concepts and techniques about 3ds Max which you can utilize to create your 3ds Max projects. This book also covers the Arnold renderer. Using a structured and pragmatic approach, this guide begins with basics of modeling, then builds on this knowledge using practical examples to enhance your modeling, texturing, lighting, and rendering skills. Each unit builds on the knowledge gained in the previous unit, showing you all the essentials of 3ds Max 2020. As you go from hands-on exercise to hands-on exercise, you'll develop a strong arsenal of skills that combined will form a complete end-to-end process to create high-quality renders using 3ds Max 2020. **Key Features** Covers 3ds Max's updated user interface, navigation, tools, functions, and commands. Explains the polygon, subdivision, and spline modeling techniques. Covers all modifiers. Covers Standard materials and lights. Covers UV mapping techniques. Covers Arnold lights, shaders, and rendering techniques. Detailed coverage of tools and features. Features 75 hands-on exercises - complete with before and after files. Features practice activities to test the knowledge gained. Additional guidance is provided in the form of tips, notes, and cautions. Important terms are in bold face so that you never miss them. The content under "What just happened?" heading explains the working of the instructions. The content under "What next?" heading tells you about the procedure you will follow after completing a step(s). Includes an ePub file that contains the color images of the screenshots/illustrations used in the textbook. These color images will help you in the learning process. This ePub file is included with the resources. Tech support from the author. Access to each exercise's initial and final states along with the resources used in hands-on exercises. Quiz to assess the knowledge. Bonus hands-on exercises. **Brief Table of Contents** This book is divided into following units: Unit DM1: Introduction to 3ds Max - I Unit DM2: Introduction to 3ds Max - II Unit DM3: Geometric Primitives and Architectural Objects Unit DM4: Polygon Modeling Unit DM5: Graphite Modeling Tools Unit DM6: Spline Modeling Unit DM7: Modifiers Unit DMB: Bonus Hands-on Exercises [Modeling] Unit DMP: Practice Activities Unit DT1: Material Editors Unit DT2: Standard Materials and Maps Unit DT3: Physical and Autodesk Materials Unit DTB: Bonus Hands-on Exercises [Texturing] Unit DL1: Standard Lighting Unit DL2: Photometric Lights Unit DL3: Sunlight and Daylight Systems Unit DA1: Introduction to Arnold Unit DA2: Arnold Lights Unit DA3: Arnold Shaders and Materials Unit DAP: Practice Activities [Arnold] Appendix DMA: Quiz Answers [Modeling] Appendix DTA: Quiz Answers [Texturing], contains quiz answers. Appendix DLA: Quiz Answers [Lighting], contains quiz answers. Appendix DAA: Quiz Answers [Arnold], contains quiz answers. For more info, visit [PADEXI ACADEMY'S](http://PADEXI.ACADEMY'S) website.

Learning 3ds Max 2010 Foundation for Games is the key to unlocking the power of Autodesk 3ds Max, directly from the creators of one of the world's most powerful 3D animation and effects software products. Get hands-on experience with the innovative tools and powerful techniques available in the new version of 3ds Max, through all new project-based lessons. Projects will include valuable game assets and examples. Topics will include modeling, animation, materials & mapping, rendering. Autodesk will be contributing assets (models and images) from high-profile studios. The DVD will include: bonus short films, demos, hotkey reference, free models from turbosquid, a \$160 value. * Only 3ds Max book to market with authoritative content approved by Autodesk - Full 4-color treatment. * Autodesk Official Training Courseware--co-published with Autodesk * Project-driven format emphasizes core skills along with software training * Valuable DVD including bonus short films, demos, hotkey reference, free models from turbosquid (value \$160).

Revitalize your architectural visualizations by bringing new levels of realism to them with an enhanced command of the mental ray toolset in 3ds Max. Full-color step-by-step tutorials give you a firm understanding of the processes and techniques needed to create impressive interior and exterior visualizations. You'll learn how to prepare materials, light a daytime interior scene, use mr Physical Sky, and how to save time during complex renders. The companion website includes all of the tutorial files and sample files from the book.

Architectural Rendering with 3ds Max and V-Ray Photorealistic Visualization CRC Press

Kelly L. Murdock's Autodesk 3ds Max 2021 Complete Reference Guide is a popular book among users new to 3ds Max and is used extensively in schools around the globe. The success of this book is found in its simple easy-to-understand explanations coupled with its even easier to follow tutorials. The tutorials are laser focused on a specific topic without any extra material, making it simple to grasp difficult concepts. The book also covers all aspects of the software, making it a valuable reference for users of all levels. The Complete Reference Guide is the ultimate book on 3ds Max, and like Autodesk's 3D animation software, it just gets better and better with each release. Whether you're new to 3ds Max or an experienced user, you'll find everything you need in this complete resource. The book kicks off with a getting started section, so beginners can jump in and begin working with 3ds Max right away. Experienced 3ds Max users will appreciate advanced coverage of features like crowd simulation, particle systems, radiosity, MAXScript and more. Over 150 tutorials – complete with before and after files – help users at all levels build real world skills.

Certified by Autodesk, Darren Brooker's new edition teaches the production techniques behind real-world work. The tutorials take you from the fundamentals of lighting, right through to advanced techniques.

Description The Autodesk 3ds Max 2019: A Detailed Guide to Modeling, Texturing, Lighting, and Rendering book is perfect for both beginners and intermediate users of 3ds Max and for those moving from other software to 3ds Max. This brilliant guide takes you step-by-step through the whole process of modeling, texturing, UV mapping, lighting, and rendering. You will learn important

concepts and techniques about 3ds Max which you can utilize to create your 3ds Max projects. This book shares tips, tricks, notes, and cautions throughout, that will help you become a better 3ds Max artist and you will be able to speed up your workflow. This book is aimed to be a solid teaching resource for learning 3ds Max. It avoids any jargon and explains concepts and techniques in an easy-to-understand manner. The first page of the every chapter summarizes the topics that will be covered in the chapter. Every chapter of this textbook contains hands-on exercises which instruct users how things can be done in 3ds Max step-by-step. Practicing is one of the best ways to improve skills. This book contains practice activities which you are highly encouraged to complete and gain confidence for real-world projects. By completing these activities, you will be able to master the powerful capabilities of 3ds Max. By the time you're done, you'll be ready to create your own projects using 3ds Max. The rich companion website PADEXI Academy contains additional resources that will help you quickly master 3ds Max. Key Features Learn 3ds Max's updated user interface, navigation, tools, functions, and commands Polygon, subdivision, and spline modeling techniques explained. All modifiers explained. Standard materials and lights explained. Arnold lights, shaders, and rendering techniques explained. Detailed coverage of tools and features. Contains 75 hands-on exercises. Contains practice activities to test the knowledge gained. Additional guidance is provided in form of tips, notes, and cautions. Important terms are in bold face so that you never miss them. The content under "What just happened?" heading explains the working of the instructions. The content under "What next?" heading tells you about the procedure you will follow after completing a step(s). Includes an ePub file that contains the color images of the screenshots/illustrations used in the textbook. These color images will help you in the learning process. This ePub file is included with the resources. Tech support from the author. Access to each exercise's initial and final states along with the resources used in hands-on exercises. Quiz to assess the knowledge. Bonus hands-on exercises. Brief Table of Contents This book is divided into following units: Unit M1: Introduction to 3ds Max -I Unit M2: Introduction to 3ds Max -II Unit M3: Geometric Primitives and Architectural Objects Unit M4: Polygon Modeling Unit M5: Graphite Modeling Tools Unit M6: Spline Modeling Unit M7: Modifiers Unit BM: Bonus Hands-on Exercises [Modeling] Unit PM: Practice Activities [Modeling] Unit T1: Material Editors Unit T2: Standard Materials and Maps Unit T3: Physical and Autodesk Materials Unit BT: Bonus Hands-on Exercises [Texturing] Unit L1: Standard Lighting Unit L2: Photometric Lights Unit L3: Sunlight and Daylight Systems Unit A1: Introduction to Arnold Unit A2: Arnold Lights Unit A3: Arnold Shaders and Materials More info: wp.me/p9r5f7-qe

* This is the only book on the market covering 3Ds max for Architectural visualizations, one of the most common uses of 3Ds Max.

* Includes quickstart tutorial sections to get the reader up and running as quickly as possible. * It will be one of the first books to come out about the new version of the product.

Increase the photorealism of your 3d visualizations with enhanced toolsets of V-Ray 5 for 3ds Max 2020. The book is filled with colorful illustrations depicting step-by-step tutorials about the process of creating a photorealistic day-and-night exterior scene. Each tutorial includes a 3d project scene to guide users through the production and the post-production processes. The book begins with an overview of the best techniques to approach clients via emails, calls, meetings, and via social media. There are also key insights into the best practices of handling projects, pricing, contracts, invoices, the pre-production, production, and the post-production, to name but a few. Throughout the book, users are taken through V-RayMtl functions such as Diffuse, Roughness, Reflect, Glossiness, Metalness, Refract, Index of Refraction (IOR), Abbe number, Fog color, Translucency, BRDF, Coat, Sheen, and Bump. Also, users will learn how to use procedural maps such as V-RayBitmap, V-RayTriplanarTex, Bricks, Metals, Carpaint, V-RayDisplacementMod, V-RayUVWRandomizer, V-RayMultiSubTex, V-RayPointCloudColor, V-RayDirt, V-RayAerialPersepective, V-RayLightMtl, V-RayMtlWrapper, V-RayOverrideMtl, V-Ray2SidedMtl, V-RayBlendMtl, and V-RayEdgesTex. In addition, there are tips and tricks accompanied with videos highlighting how to create VR interactive apps using Verge 3d; how to create verified views; and how to use plug-ins and scripts such as Project Manager, Auto grid pivot point, GarageFarm, Zmapping, gobotree, and VIShopper. Finally, users will have a rare insight into all functionalities of a V-Ray camera, V-RayLight objects, Render settings, Frame buffer, Global switches, IPR options, Bucket and Progressive image samplers, Image filters, Global DMC, Color mapping, Brute force global illumination, Light cache, Color management, Distributed rendering, Render elements, V-Ray image file format, VFB History settings, VFB Lens Effects, LightMix, Film tonemap, Hue/Saturation, Lookup Table, and much more. Key Features This book deals with real projects/3d scenes and delivers up-to-date V-Ray 5 functionalities and production workflows using 3ds Max 2020 This book has professional supporting files ready to open and explore This book details the meticulous step-by-step processes of creating jaw-dropping 3d renderings This book includes unrivaled in-depth coverage of V-Ray 5 for 3ds Max 2020 This book includes 3d rendering methodologies currently used by key industry players Author Jamie Cardoso is a renowned author, reviewer, computer artist, and technologist, with years of experience in creating state-of-the-art 3d photomontages, verified views, VR, AR, XR, MR, Stereos, and photorealistic interior and exterior visualizations for architects and designers.

"Mental ray" is one of the leading rendering engines for generating photorealistic images. On the one hand the text provides a general introduction into rendering with mental ray, whilst on the other, it includes tips and tricks for advanced and professional users. A comprehensive definition of mental ray's scene description language and the standard shader libraries are included and used as the basis for all examples. This second edition covers the new generation of mental ray, version 3.0. The text is accompanied by a CD-ROM, featuring a fully programmable demo version of the software together with example scene data and shaders. An excellent text for both beginners and advanced users of mental ray.

The sure way for design professionals to learn SketchUp modeling and rendering techniques Rendering In SketchUp provides instructions for creating 3D photoreal graphics for SketchUp models using integrated rendering programs. The book serves as a beginner rendering manual and reference guide to further develop rendering skills. With an emphasis on step-by-step process, SketchUp users learn a universal approach to rendering varied SketchUp projects, including architecture, interiors, and site design models. The book focuses on tasks and principles at the core of photorealistic rendering, including: Rendering process: Learn a step-by-step process focused on workflow within SketchUp's familiar workspace. Universal method: Understand how the process can be used to work with a variety of different integrated rendering programs, including Shaderlight, SU Podium and Twilight Render**. These programs are easy to learn and function in SketchUp. > Textures and materials: Discover how to obtain, apply and edit texture images representing surfaces. Component details: Learn how to acquire and organize model details to allow for rich, expressive settings while maintaining computer and SketchUp performance. Exterior and simulated lighting: Learn to set exterior lighting with the SketchUp's Shadow menu or illuminate a scene with simulated lights, lamps, and bulbs. Render settings: Use specific settings for various rendering programs to quickly set texture character, image quality, and graphic output. Computer specifications: Find out how computers produce renders and the type of computer hardware required to streamline the process.

