

SECOND EDITION

**THE
THE PAST, PRESENT AND FUTURE
OF
VISUAL AND OPTICAL
PERSPECTIVE**

The Art and Science of Perspective

ALAN STUART RADLEY

PAST, PRESENT AND FUTURE
OF
VISUAL AND OPTICAL
PERSPECTIVE

THE ART AND SCIENCE OF PERSPECTIVE

SERIES VOLUMES

1. Past, Present and Future of Visual and Optical Perspective
2. Dictionary of Perspective
3. Natural and Visual Perspective
4. Graphical and Mathematical Perspective
5. Simulated Perspective and Illusion
6. Instrument and New Media Perspective

Past, Present and Future
Of
Visual and Optical
Perspective

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THE
ART AND SCIENCE
OF
PERSPECTIVE

- VOLUME ONE -

SECOND EDITION
2026

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Blackpool, England

Past, Present and Future of Visual and Optical Perspective

Alan Stuart Radley

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for

Kim Veltman

and

Philip and Ellen Radley

BOOK SERIES AND VOLUME ONE

For more than five centuries, perspective has occupied a central place in the study of art, optics, geometry, architecture, astronomy, surveying and representation. Today, its principles remain fundamental to photography, cinema, cartography, computer graphics, visual perception, scientific imaging, virtual and augmented reality, artificial intelligence, and many other technologies of seeing and spatial representation.

Perspective is nevertheless dispersed across numerous disciplines and is seldom treated as a coherent field of knowledge. *The Art and Science of Perspective* is a six-volume monograph intended to gather, explain and connect the principles, categories, types, forms, methods, instruments, systems, applications and phenomena of visual and optical perspective.

Past, Present and Future of Visual and Optical Perspective is Volume One of the series. It provides an illustrated introduction to the field, tracing selected developments from ancient theories and methods to Renaissance linear perspective, optical instruments, photography, cinema, computer graphics, scientific imaging, New Media and emerging visual technologies. It is not intended as an exhaustive history or mathematical treatise. Rather, it introduces the principal ideas and application areas examined in greater depth throughout the series.

Volume Two, *Dictionary of Perspective*, provides the principal terminological and categorical reference for the monograph. It contains approximately 4,000 terms, including about 1,200 types and forms of perspective. The remaining volumes examine natural and visual perspective; graphical and mathematical perspective; simulated perspective and illusion; instrument and New Media perspective.

The diverse principles and methods of perspective are a bedrock to the development and progress of human civilisation.

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ABOUT THE SECOND EDITION

This second edition retains the principal structure, historical material, illustrations and application surveys of the first edition while updating its terminology and theoretical framework to correspond with the second edition of *Dictionary of Perspective*.

The principal revision concerns Perspective Category Theory. The revised theory distinguishes perspective categories, classes, types and forms. Categories identify the principal source or mode of a perspective process. Classes identify the two principal directions in which perspective operates: the backward or image-forming direction of the Viewing or Imaging Class, and the forward or image-projecting direction of the Projecting Class.

Visual Perspective Type 1 is treated as the broad category encompassing direct and represented visible appearances, views and images. Visual Perspective Type 2 is the human retinal and perceptual subclass within Type 1. Representing, measuring, matching, modelling, creating illusion and producing immersion are treated as functions, goals or outcomes rather than as additional basic classes.

The revised framework also clarifies how several perspective categories may operate together or in sequence through category chaining, category overloading and composite perspective. It distinguishes the perspective method or process from the resulting image, view, representation or spatial appearance.

Scope of this Volume

This volume introduces the breadth, history, principles and future scope of visual and optical perspective. It is intended as a foundational survey of the field rather than an exhaustive technical treatment of every concept, method or construction presented.

Subjects introduced here—including ray-based analysis, graphical construction, optical systems and specialised forms of perspective—serve as preliminary illustrations of principles that will be developed systematically in later volumes of *The Art and Science of Perspective*. They should therefore be understood as previews and evidence of the field's wider structure, rather than as complete technical lessons.

PREFACE

Perspective concerns the ways in which spatial objects, scenes, views and images are observed, formed, projected, measured, represented, simulated, transformed and experienced. It includes natural and visual appearance, optics, geometry, drawing, painting, photography, cinema, scientific imaging, instruments, computer graphics, virtual environments and many other methods of viewing and spatial representation.

Given the familiarity of linear perspective and perspective drawing, one might assume that the subject is already fully understood. Nothing could be further from the truth. Perspective is a broad, technically complex and rapidly developing interdisciplinary field. Its concepts are distributed across art, optics, geometry, visual perception, photography, filmmaking, architecture, engineering, cartography, scientific imaging and computational media.

The traditional graphical method of linear perspective is only one part of this field. *Dictionary of Perspective*, which accompanies the present volume, contains approximately 4,000 terms, including about 1,200 types and forms of perspective. Some describe established historical and graphical methods; others concern optical instruments, photography, cinema, computer vision, artificial intelligence, virtual reality, visual perception, illusion, immersion and emerging technologies.

Perspective terminology is unusually difficult because one concept may possess several names, while one name may refer to different methods, processes, systems, image forms or phenomena. Perspective processes may also combine or operate sequentially. The revised Perspective Category Theory developed for this series therefore distinguishes categories, directional classes, types, forms, functions and outcomes while clarifying the relationships between them.

This volume introduces the past, present and possible future of visual and optical perspective. It examines historical developments, theoretical principles, types and forms, imaging and physical applications, visual illusions, current technologies, future possibilities and the role of the human visual system. It is intended to provide an accessible illustrated introduction and a foundation for the more detailed volumes of *The Art and Science of Perspective*.

Perspective remains one of the most fundamental means by which human beings view, understand, measure, model, represent and explore spatial reality. Its diverse principles and methods continue to influence the development of art, science, technology and civilisation.

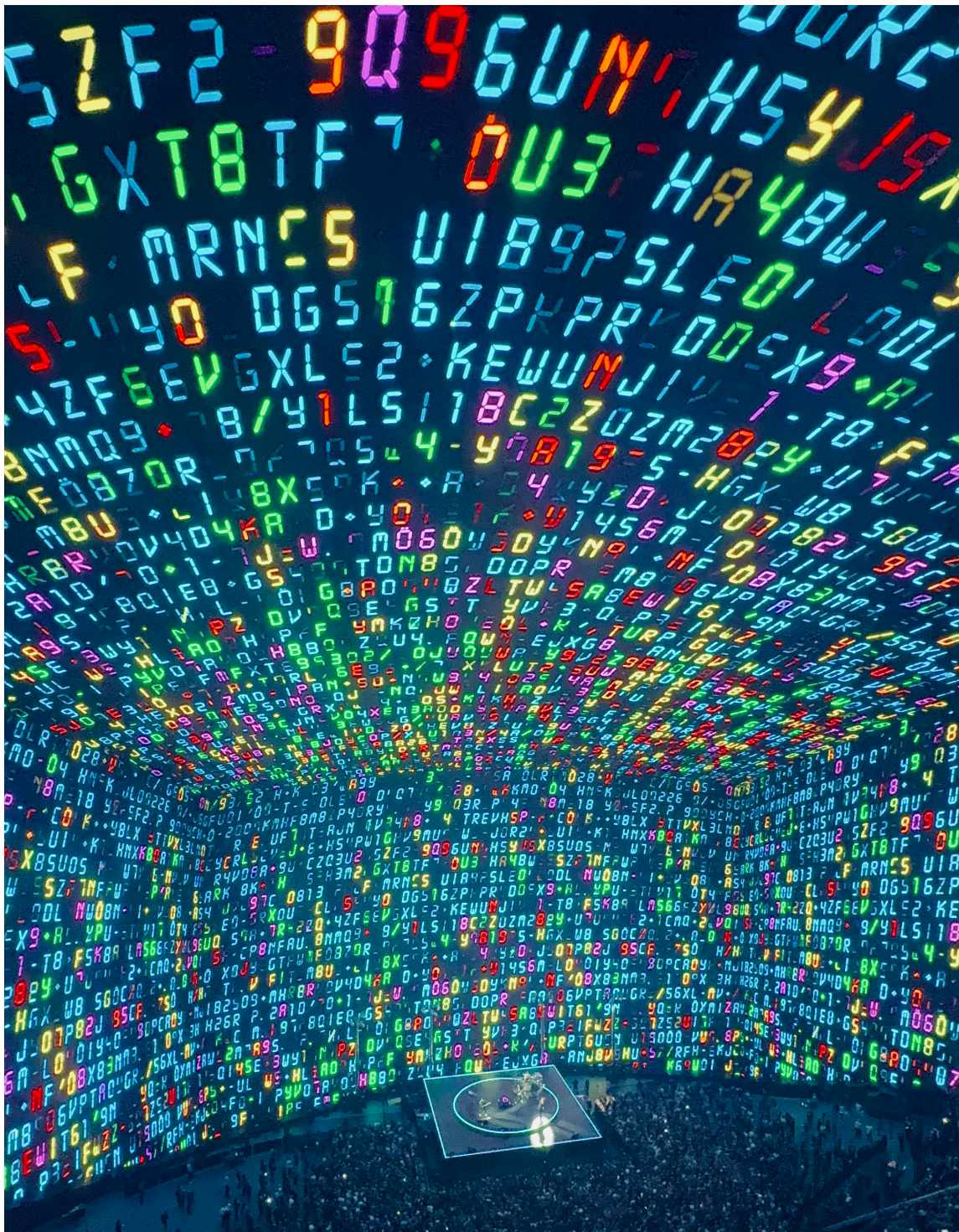


Figure 1: Sphere, Las Vegas (2023).

Sphere's approximately 15,000 m² interior LED display plane has 16K × 16K resolution and wraps up, over and around the audience, enabling immersive perspective imagery.

Introduction

IN A STRANGE quirk of fate, to the author's knowledge, no single work has attempted to define, analyse and unify all the principal categories, classes, types, forms, methods, instruments, systems and applications of visual and optical perspective. A first goal is therefore to gather the principal knowledge on this subject into a comprehensive multi-volume monograph entitled *The Art and Science of Perspective*. The series explores the elementary foundations of perspective and identifies its principal categories and directional classes, together with numerous types, forms and subcategories. It seeks to minimise the number of primitive notions, axioms, principles and inference rules required to relate perspective phenomena, while connecting the principal theories that comprise the subject, past and present.

Desired are solutions to the paradoxes that have plagued perspective theories/methods throughout time, including the debate(s) over the nature of human vision and whether perspective is an objective or subjective method. Whilst it is certainly not possible to solve all such problems in this work, we aim to comprehensively identify and describe the nature and implications of many of these same issues. We wish to spark interest in visual and optical perspective, advance the subject by popularising it, and showcase the powers and capacities of related visual, imaging, and spatial concepts.

A second goal is for the monograph to serve as a repository of common terms, concepts and methods used across the field of perspective, and as a trusted source for perspectivists and others in art, science or technology who must understand parts of this complex field. Perspective views and images can be extraordinarily complex, comprising multiple interrelated optical phenomena, categories, types and forms, visual layers and components, and chains of image-forming and image-projecting processes. Perspective Category Theory is introduced to help clarify this complexity, improve the analysis and real-time comprehension of perspective images, support their efficient capture, creation and use, and expand their range of applications.

1986–1996
Studies on
Leonardo da Vinci

1994–2020
*The Encyclopedia of
Perspective*

Kim H. Veltman
[1948–2020]

Professor Kim H. Veltman [1948–2020] produced the first truly comprehensive monographs on perspective, running to approximately 4,000 pages across 17 volumes and providing modern scholars with an extensive historical overview and bibliography of the primary and secondary literature. These works provide an exceptional historical and bibliographical foundation, but their principal purpose was not to establish a unified technical framework for visual and optical perspective. The present series supplements them in that respect.

The Art and Science of Perspective provides a central core of practical knowledge on visual and optical perspective, including Natural, Visual, Optical, Mathematical, Graphical, Instrument, Simulated and New Media Perspective. We exclude arcane mathematical proofs and extended philosophical discussions, limiting the exposition mainly to practical topics that affect real-world perspective phenomena, methods and applications. The analysis is multifocal, connecting art, science and technology.

Natural Perspective
Visual Perspective Type 1
Visual Perspective Type 2
Optical Perspective
Mathematical
Perspective
Graphical Perspective
Instrument Perspective
Simulated Perspective
New Media Perspective

Perspective is broadly defined as the formation, projection, representation, transformation or experience of a view, image or spatial appearance in relation to an object, scene or spatial reality. This monograph concentrates on visual and optical perspective and on the mathematical, graphical, instrument, simulated and New Media processes closely related to them. In this work, optical perspective is used in an extended sense for processes involving light or other electromagnetic radiation in the formation, transmission, measurement or projection of spatial views and images, including visible light and other wavelength ranges. Excluded are contact perspective, symbolic or metaphorical uses of the term, and purely algebraic forms of mathematical representation that do not directly concern visual images.

All categories of visual and optical perspective have important relationships with mathematics, and most images are ultimately subject to the characteristics of human vision and perception. Perspective therefore raises fundamental questions about the nature and limits of human perception and understanding of spatial reality—problems that have puzzled scholars for more than 2,000 years and remain debated today. We shall accordingly consider human vision and visual perception, including physical, physiological and psychological optics.

Optical Perspective may operate in either directional class. In the Viewing or Imaging Class, light or electromagnetic radiation travels from an object or scene to an eye, sensor or imaging system, where a view or image is formed, captured, measured or perceived. In the Projecting Class, light or images are projected into physical, graphical, optical or simulated space. Some New Media methods use computational rather than physical rays.

Kim Veltman's works concern the history, literature and bibliography of perspective:

1. Studies on Leonardo da Vinci 1: Linear Perspective and the Visual Dimensions of Science and Art, 1986.
2. Studies on Leonardo da Vinci 2: Continuity and Discovery in Optics and Astronomy, 1996 (8 volumes).
3. The Sources of Perspective, 1994–2020 (published as the Encyclopedia of Perspective, Volumes 1 and 2).
4. The Literature of Perspective, 1994–2020 (published as the Encyclopedia of Perspective, Volumes 3–5).
5. The Bibliography of Perspective, 1994–2020 (published as the Encyclopedia of Perspective, Volumes 6–8).

These techniques may operate across extremely large or small spatial scales, or use radiation that penetrates solid objects to produce images of otherwise hidden structures. Such images may be false-colour, reconstructed or instrument-mediated, but they can nevertheless provide accurate and useful representations of spatial reality. Light-ray models and visual and spatial reasoning are also fundamental to many forms of imaging and human cognition.

In this monograph, optical perspective is used in the extended sense defined on the preceding page. Technical perspective may be used as a broad descriptive expression for systematic methods of viewing, imaging, measuring, constructing, projecting or representing spatial objects and scenes, but it is not treated as a separate principal category. Processes based primarily on sound, magnetic fields, mechanical contact or gravity are not treated as Optical Perspective, although their data may enter the wider field when converted into visual representations.

Visual and optical perspective are simultaneously old and new fields. They include established theories and methods, such as graphical linear perspective and optical instrument imaging, while new forms continue to arise through digital technologies and New Media. New Media Perspective is generated, processed, displayed or explored through computational and electronic media. Such systems may combine multiple instrument and computational processes.

Examples include Internet and web-based information systems, networked cameras and telescopes, Internet of Things (IoT) frameworks, remote-sensing instruments and satellite imaging systems, digital television, smartphones, GPS, computer graphics, computer vision, artificial intelligence, and virtual, augmented, mixed and extended reality.

In developed New Media systems, images and views from several perspective categories may be captured, connected, processed, modelled, matched, mixed, explored and displayed. Categories may operate sequentially through category chaining or overlap through category overloading, producing composite perspective processes, systems and images. A key part of this series is therefore to identify and analyse the types, functions and implications of New Media Perspective and its relationships with more traditional forms of visual and optical perspective.

Visual Perspective Type 1
Optical Perspective
Instrument Perspective
New Media Perspective

New Media

Internet
Robotics
Autonomous Systems
Artificial Intelligence
Networked Systems
Internet of Things
Remote Sensing
Virtual Reality
Augmented Reality
Mixed Reality
Extended Reality
Digital Metaverse
Digital Multiverse
Digital Filmmaking
Virtual Production
Computer Games
GIS / GPS
CGI / CAD / AI
CV / MI / SFX / VFX

¹ **New Media Perspective:** Perspective generated, processed, displayed or explored through computational and electronic media. It includes digital imaging, computer graphics, computer vision, artificial intelligence, virtual reality, augmented reality, mixed reality and interactive 3-D environments. The term may refer to a method or process and/or to the resulting image, view or spatial appearance.

Painted / Photographic / Physical + CGI Reality
 Natural Scene / Artificial Representation / Composite Perspective

Graphical / CGI / Mixed / Synthetic / Linear / Spherical /
 Simulated / Blended / New Media / Combined Perspective

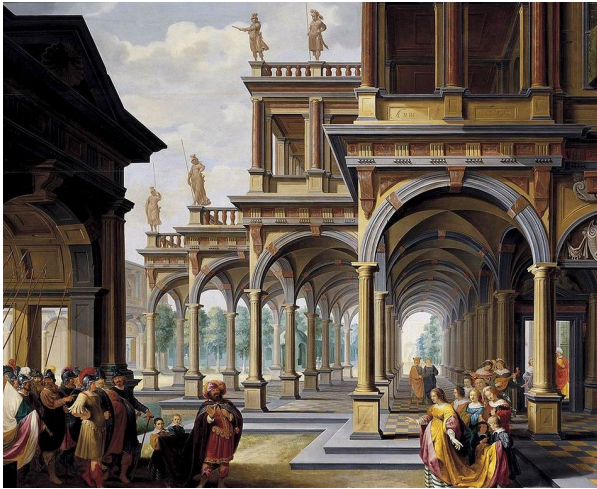


Figure 2: Natural, artificial, simulated and composite perspective.

Perspective categories may overlap or operate sequentially through category overloading and category chaining, producing composite perspective systems and images. For example, Visual, Optical, Instrument and New Media Perspective may all contribute to a single image.

For an author to make any predictions regarding the future of New Media perspective is a perilous activity. New digital inventions are coming fast, furious, and everywhere. To avoid false conclusions, our focus is on the fundamental principles, methods, and functions of perspective, which can be (at least partially) foreseen ahead of technological breakthroughs.

Once again, we are gathering a comprehensive body of knowledge on visual and optical perspective into a monograph entitled *The Art and Science of Perspective*. These books will be of interest to vision-based professionals, including artists, photographers, filmmakers, cinematographers, architects, lighting designers, CAD engineers, VR/AR/MR developers, digital-metaverse content creators, 3-D/CGI/AI modellers, SFX/VFX creators, game designers and live, virtual and hybrid film-production specialists.

The monograph comprises six volumes:

1. Past, Present and Future of Visual and Optical Perspective
2. Dictionary of Perspective
3. Natural and Visual Perspective
4. Graphical and Mathematical Perspective
5. Simulated Perspective and Illusion
6. Instrument and New Media Perspective

Volumes One and Two have been published first because the introductory material, definitions and theoretical framework they contain are essential to understanding the subsequent volumes. The remaining volumes are in preparation.

Terminology is important. In the field of perspective, concepts often have multiple names, and a single name may refer to different or even opposite ideas.² We shall cross-reference these names and link them to preferred or standard terms. Established terminology is used wherever possible, but new or refined concepts sometimes require new terms. Detailed optical-ray and geometrical construction diagrams are largely reserved for the relevant later volumes; selected illustrations remain in Volume One, while supplementary diagrams accompanying the Dictionary are available online. Together, the series is intended to provide a comprehensive survey of visual and optical perspective.

Let us now begin the epic story of perspective by considering what it actually is, how it has profoundly shaped human activities, and what it means for the development of human civilisation.

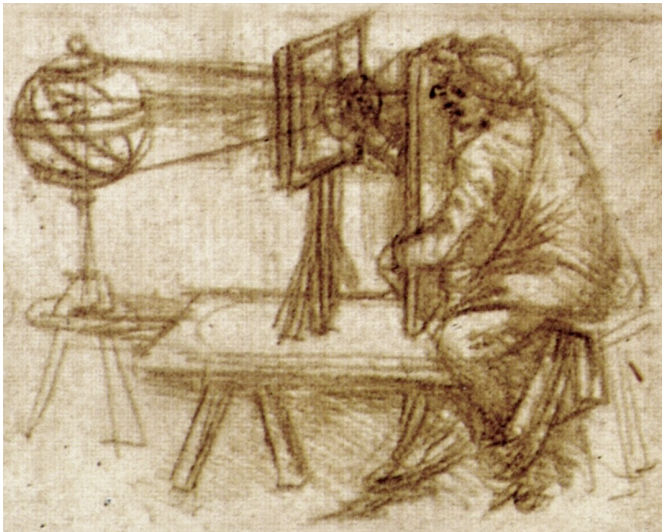
Professions

Artists
Scientists
Technologists
Filmmakers
Cinematographers
Architects
Lighting Designers
CAD Engineers
VR/AR Engineers
Metaverse
Developers
Game Designers
3-D / CGI Modellers
SFX / VFX Creators
Live Film Production
Virtual Production
Hybrid Production

Terminology

Multiple Names
Multiple Meanings

² **Linear Perspective:** Linear perspective has been described by numerous names and related terms. Some are synonyms or historical variants, while others denote particular orientations, constructions, applications or subtypes. Names and related terms: analytic, artificial, academic, artists, ideal, old, modern, European, basic, correct, angular (type 1), classical, albertian, quattrocento, brunelleschian, Renaissance, Italian, common, normal, horizontal, traditional, orthodox, conventional, diagonal, geometrical, practical, standard, window, one-eyed, chessboard, chequerboard, front, frontal, eye-level, central, central-point, one-point, single-point, two-point, three-point, multi-point, unlimited-point, point-projection, plane-projection, western, picture, level-plane, rectilinear, equi-rectilinear, conic, conical, pictorial, perspective of lines/outlines, pyramid of spatial recession, receding, triangular, triaxial, flat picture plane, focal, lineal, measured, pin-hole camera perspective(s).



Perspectograph

Use of a glass, veil, perspective window, or perspective 'net', plus fixed eye-point, to make an accurate perspective drawing of an armillary sphere.

Leonardo da Vinci

Codex Atlanticus, c. 1478–1519

Drawing / Graphical / Visual Perspective Type 1



The Last Supper, Leonardo da Vinci, c. 1495–1498

On Perspective

The art of perspective is to make what is flat
appear in relief, and what is in relief flat.

Leonardo da Vinci



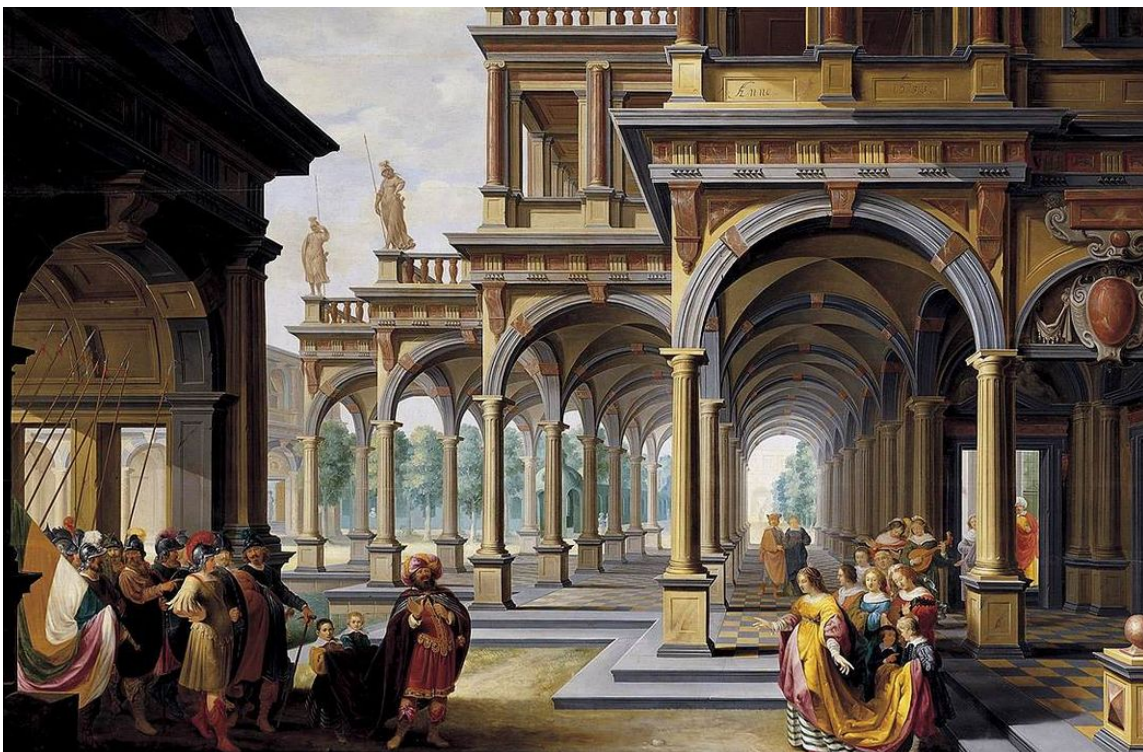


Figure 3: Graphical Perspective (paintings)

Top: Graphical / painting perspective by Canaletto, c.1733.
Bottom: Graphical / painting perspective by Dirck van Delen, c.1633.

On Perspective

PERSPECTIVE is one of our principal methods for visualising and representing the world, treating depth and scale systematically, and establishing standards of spatial correspondence. It operates in two directions. In the backward or image-forming direction, light or spatial information passes from an object or scene to an eye, sensor or imaging system. In the forward or projecting direction, light, images, shadows, lines or spatial information are projected from a source into physical, graphical, optical or simulated space. Perspective thereby supports the analysis, representation and transformation of spatial reality.

Visual or optical perspective concerns the changing appearance of things when observed from a particular viewpoint or series of viewpoints, especially as they extend into the third dimension or depth. A familiar form of graphical and mathematical perspective is Renaissance linear perspective, which rationalises spatial representation by framing, segmenting, ordering, indexing, measuring, mapping and gauging physical space. Perspective is a multifaceted subject that covers a far wider range of visual phenomena than many realise, and is a key to understanding major categories of art/science/technology over the past 500 years. Related topics include *space, time, optics, human eye/vision, colour, drawing, mathematics and geometry, reality, illusion, immersion, imagination, and representation*.

Perspective is central to key developments across subjects such as *art, photography, television, cinema, cartography, astronomy, topology, photogrammetry, scenography, archaeology, architecture, gardens and the environment*. Recent developments have strong links to perspective, such as *Geographical Information Systems, Computer-Generated Imagery, Computer-Aided Design, Special Effects, Virtual/Augmented/Mixed Reality, Medical Imaging, robotic vision, drones, etc.*

Perspective emerged in prehistory as a fragmented and often unconscious set of methods for enhancing realism. In the ancient world, it was used in painting and architecture to create illusionistic spatial effects. During the Renaissance, it became mathematically codified as a method for constructing systematic dimensional spaces. In modern times, perspective has supported scientific theory, architectural and engineering accuracy, remote sensing, digital communication and the imaging of spatial reality.

Italian Renaissance
1350–1550

1415–1420
Linear Perspective
Filippo Brunelleschi
[1377–1446]

Rationalises
Vision
Framing
Segmenting
Ordering
Indexing
Measuring
Mapping
Gauging

Subjects
Art
Photography
Television
Cinema
Cartography
Astronomy
Topology
Photogrammetry
Scenography
Archaeology
Architecture
Gardens

³ 'Perspectiva', says Dürer, 'is a Latin word and means "Durchsehung": a view through something [physical space]'. But perspective also refers to **perspicere** in looking directly at something or 'seeing a form clearly' with your eyes [ref. view of a spatial scene/object].

Renaissance Perspective: One-point perspective is a graphical construction on a two-dimensional picture plane using a fixed station point. Lines orthogonal to the picture plane converge towards the central vanishing point on the horizon line. Other families of receding parallel lines may have different vanishing points, while lines parallel to the picture plane remain parallel.

Viewing
Matching
Representing
Illusion
Immersion
Projecting
Measuring
Modelling

Drawing
Architectural
Engineering
Industrial
Map / Plan
Machine
Technical
Engineering

Subjects
Optics
Statics
Hydrostatics
Nautical Science
Architecture
Machines
Geography
Astronomy
Nuclear Physics
Chemistry
Biology
Chronology
Space Flight

Perspective provides new powers to visualise, model, and create/apply scientific solutions to problems of unprecedented scale, scope, depth, context, detail, and accuracy. It introduced new ways of **viewing**, **matching**, **representing**, creating convincing **illusions** of, and inducing apparent **immersion in** spatial reality. Perspective lies close to the centre of many developments in visual, spatial and imaging technology and will remain important to future progress.

Perspective affects appearance and representation, influencing *visual arts, sculpture, decorative arts, performing arts, and architecture*. Let us begin with the making of perspective drawings and paintings. For reasons of brevity, we shall not survey the full history of drawing here; it is sufficient to note that one important development sought increasingly realistic representations of physical reality. Perspective played an important role in depicting spatial effects, especially the illusion of depth [10,13,14]. Overall, by the 19th century, ever more specific branches of perspective drawing were introduced, including: *architectural, engineering, industrial, map, plan, technical drawings, etc.* These methods were codified into so-called *machine/engineering-drawing, geometrical/technical-drawing and/or mechanical-drawing*. These methods became important tools of industrial design and manufacture and later supported computer-aided design, satellite engineering and space technology [10,21].

Perspective—in a variety of forms—is one of the fundamental techniques involved in the generation and viewing of artistic creations. However, as indicated, the applications of perspective are by no means limited to art and design. The various perspective principles, theories, types/forms, methods, and instruments have been indispensable to the development of human civilisation as it exists today. Perspective supports progress across many areas. Ergo, perspective is not merely of theoretical, aesthetic or incidental interest.

In terms of science, it is known that the development of perspective was integrally connected to the rise of instrumentation, which focused attention on proportion, scale, and, finally, quantification. In the process, perspective contributed to visual standards of scientific evidence and supported the development of increasingly systematic observation, experiment and measurement [10,13,14,15]. Hence, perspective provided methods for systematically constructing and recording views of the physical world, reinforcing the philosophical distinction between subject and object.

Today, 'agentic' AI systems seek to take autonomous action in the real world. Likewise, in earlier times, perspective unlocked detailed planning/design of spatial solutions to address physical problems with accuracy and precision.

Perspective enabled systematised models to be developed on media, providing great precision and explanative power to scientific experiments [10]. Perspective theory has been explicitly employed to aid in the development of new scientific theories. In terms of the theoretical influences of perspective, we find innumerable examples throughout history. Perspectival methods, diagrams and instruments influenced or supported work in optics, astronomy, cartography, physics and other sciences, including work associated with Euclid, Ptolemy, Copernicus, Galileo and Newton. These developments contributed substantially to the scientific culture of today.

Perspective has also influenced technological developments in two primary ways. Firstly, instruments associated with perspective, optics, navigation and surveying enabled increasingly accurate measurements and representations of the physical world [13,15]. Instruments associated with perspective, spatial measurement, navigation, astronomy and surveying include: for navigation and surveying—the quadrant, octant, compass, sextant and theodolite; for astronomy and optics—the astrolabe, armillary sphere, telescope and spectroscope; and for drawing and measurement—the perspectograph, proportional compass or sector, and callipers.

Concurrent with key breakthroughs in mathematics, geometry, and physics, perspective contributed to increasingly systematic understanding and representation of the physical world, supporting many later innovations. Secondly, we have the application of perspective to practical disciplines. Subjects influenced by perspective methods include: *optics, statics, hydrostatics, nautical science, architecture, machines, geography, astronomy, nuclear physics, chemistry, biology, and chronology*.

Perspective techniques were used to produce detailed engineering drawings. Accurately scaled and correctly proportioned drawings could be produced using plans, elevations and sectional elevations. Such drawings could then be used as blueprints for manufacture. Such drawings fostered systematic, scientific and spatial modes of thought and supported the development of new instruments, mechanisms, machines and working methods. Manufacturing capability exploded as a result. Vastly improved working efficiency followed, which magnified human physical powers and enabled a wide range of automation technologies, leading to steam engines, automobiles, aeroplanes, etc. [10].

Perspectivists

Euclid

Ptolemy

Copernicus

Galileo

Newton

Navigation

Quadrant

Octant

Cosmolabe

Compass

Sextant

Sector

Sundial

Astronomy

Orrery

Celestial Globe

Astrolabe

Armillary Sphere

Planisphere

Sundial

Telescope

Spectroscope

Cartography

Staff

Compass

Calliper

Theodolite

Maps

Terrestrial Globe

Instruments / Displays

Panorama
Cyclorama
Stereoscopy
Magic Lantern
Camera Obscura
Camera Lucida

Overall, it is difficult to imagine that the explosion in science, engineering, and technology over the last 500 years could have occurred without an intimate knowledge of perspective and its various mathematical forms and practical methods. Perspective is truly a keystone of civilisation.

New perspectival images led to an emphasis on *illusionism* and *trompe-l'oeil* (highly realistic optical illusions), blurring the boundaries between the natural and the fictive, which inspired an extraordinary proliferation of visual images. Herein lies the true value and significance of linear or scientific perspective (graphical/mathematical form): not simply as a tool for realism, but as a catalyst to our imagination, playfulness, creativity, and freedom. Perspective amplified visual powers and boosted mental outlooks. Perspective brought mimesis and spatial illusion into a newly systematic geometrical relationship, amplifying human understanding of, and power over, physical representation.

Perspectival Nature of Reality

Optical Processes
Perceptual Processes
Mental Processes
Truth / Illusion

Knowledge of perspective contributed to the development and use of numerous visual instruments and displays, including: *panoramas*, *cycloramas*, *stereoscopic devices*, *magic lanterns*, *the camera obscura* and *camera lucida*, etc., and it also played a key role in the development of photographic cameras, and has been pivotal to progress in cinema/movies/television [10,13,14,15].⁴ Different forms of perspective emphasised the plasticity of images, and hence the role of illusion and multiple truths, which may be possible not only in the imagination but also in perceiving objects in the real world. Perspective drew attention to the **perspectival nature of reality**, and the various processes—optical, perceptual, mental—that are ongoing between *viewer*, *object* and *image*, and further to relations between objective **truth** and subjective **illusion**.

Putting aside all technical details, people often fail to realise why perspective is such an important topic. An answer is that perspective draws attention to the distinction between subject and object, and inspires a fascination with views, which developed along three broad, parallel lines.

Perspective Views Provide

Realism
Illusion / Immersion
Enhance Reality

- One sought accurate representation or **realism**, leading to *topographical views*, *geometrical and architectural drawings*—and, hence, to faithful copying of environmental appearances.
- The second type of view was aimed at **illusion/immersion**, which led to *panoramic, distorted, imaginative, and illusionistic spaces*.
- A third type of view emerged when perspective was employed to **enhance physical reality**, seen as a quest for certification of sight, measurement, and representation, leading to *accurate views, maps, and models*. In this manner, we can develop and test our theories of the real world [10,13,14,15].

⁴ **Magic Lantern:** An early projector developed in the 17th century using transparent images and a light source, with slides inserted upside down to correctly orient projections.

Camera Obscura: A natural phenomenon where light through a small hole projects an inverted image in a dark space. It also denotes a dark room or box used to project external scenes.

Camera Lucida: An optical drawing aid that allows the observer to see a virtual image of the subject superimposed upon the drawing surface, enabling its outlines and key points to be traced accurately.

Concordant with such developments has been the use of perspective to aid in the accurate analysis and understanding of views/images, specifically for mapping environments and creating new environments. Both are made possible through a host of perspective principles, methods, and instruments, such as the *sextant, compass, camera, telescope, and microscope*.

Notably, many of these developments have profoundly improved human knowledge, understanding, and, ultimately, consciousness of physical reality, thereby leading to an ever-increasing ability to probe, model, control, and shape the world in which we live. Perspective has been a foundation of human imaginative and creative potentials throughout time. Almost all sighted humans naturally form visual, apparently three-dimensional (3-D) images of things and processes in their minds. We run little ‘movie’ scenarios using our ‘inner eye’, conveying happenings as perspective views of scenes—forming mental or imaginary perspectives. The ways in which imagination models and shapes reality may be influenced by the forms and sophistication of the perspective theories, methods and systems available within a culture.

By accurately **prescribing, indexing, and modelling physical reality**, perspective enabled the development and subsequent recording of accurate, systemised worlds. Ultimately, we use pen/paper or computers to record perspective images/models, thus making explicit what had previously been only mental, poorly specified, or implicit. Perspective is a 3-D experimental sandbox for the mind—allowing us to visualise all of the (spatial) possibilities!

The explicit dimensional worlds made possible using perspective methods/instruments enable new ideas, concepts, forms, and conglomerations of objects to be explored (and recorded/preserved plus shared). Some objects or processes are real or already existing, and some are only imaginary or preliminary plans (at a particular time). Using perspective, object and process designs were developable, testable, and composable in new ways that often could not be attempted in the real world due to a lack of possibility; either because said design breaks the rules of physics (unknowingly prior to modelling), or due to a lack of space, time, and energy, or else a lack of resources with which to explore said structural possibilities adequately. Ergo, we no longer needed to try everything out in reality. The inner world became the master and shaper of the outer.

One key to progress is accurate representation: real-world information is captured, processed, indexed and rapidly accessed. Perspective thereby helps humans map, model and shape physical reality [10,13,14].

Physical Reality

Prescribe

Index

Model

Explicit Dimensional Worlds

Object / Process
Modelling

Inner World is
Master and
Shaper of Outer

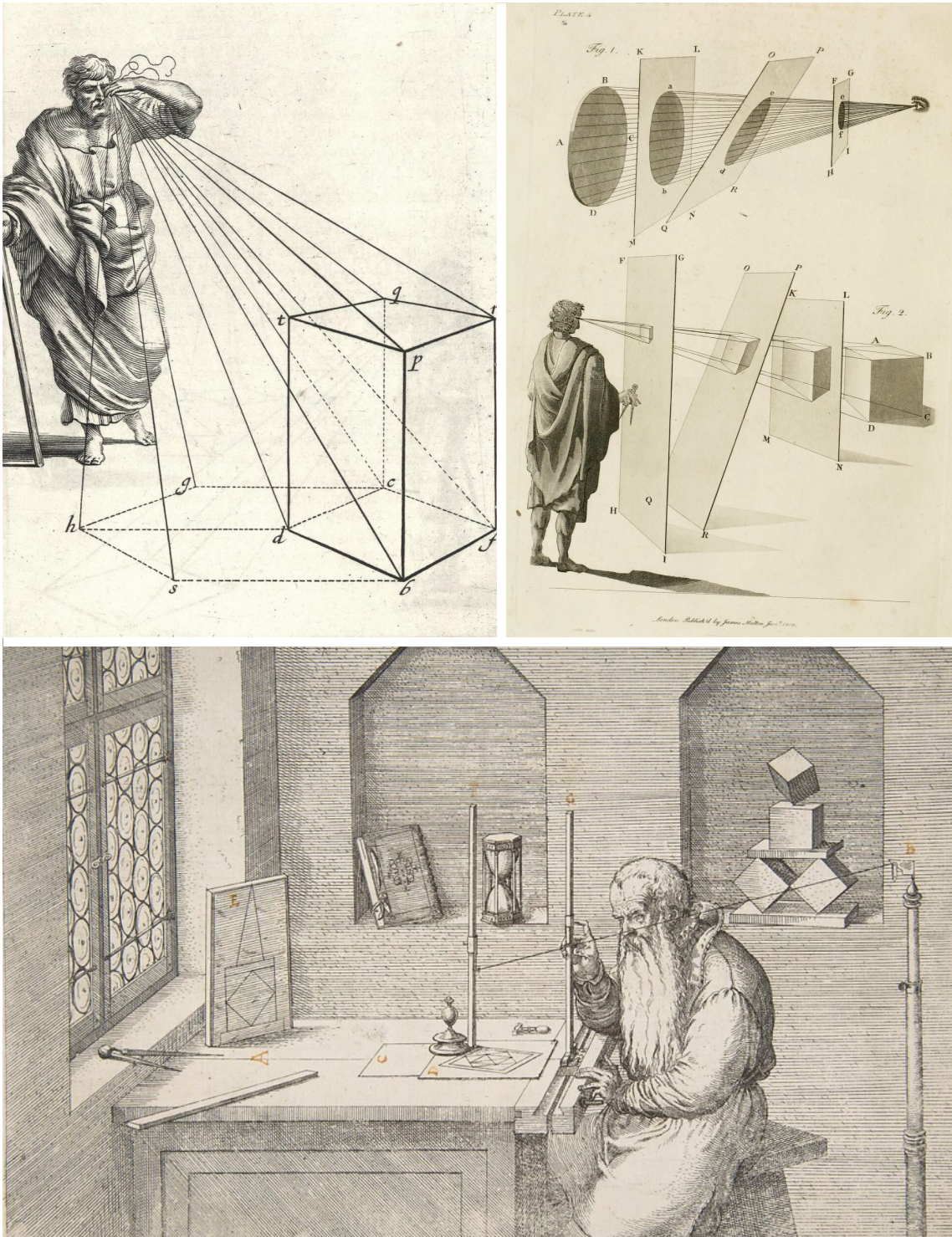


Figure 4: Visual / Graphical Perspective

Top (left): Perspective diagram by James Malton, 1800.
Top (right): Perspective diagram by Abraham Bosse, 1648.
Bottom: Using a perspective instrument to construct a perspective drawing, c.1610.

Today, we live in a new universe of the internet and digital media, in which inert objects all around us are suddenly waking up and becoming ‘smart’. Regardless of whether we see the digital universe as being inside the real universe—or vice-versa—it remains the case that the various methods of perspective can help us (plus the machines/AIs) to more accurately, rapidly, and efficiently meet the six stages of representation as identified by Kim Veltman: connecting, ordering, mimesis, matching, mixing, and exploring (*Encyclopedia of Perspective*, Volumes 1 and 2).

According to Kim Veltman, a further goal is cross-matching: comparing and relating images, models and information across different systems, media and contexts. New hybrid perspectives will doubtless be developed to extend this process and advance the cross-matching goal. Humans and intelligent machines will together generate ever more complex, realistic, real-time, and helpful (perspective) representations of physical reality. Overall, perspective has a fundamental influence on *art, science, engineering, technology, phantasy, and illusion*, etc. Fields such as *astronomy, architecture, navigation, surveying and map-making* could not have developed into systematic disciplines without perspective principles and methods for organising, measuring and representing spatial views.

Perspective should be recognised as a primary branch of knowledge—or an academic field in its own right. Perspective has strongly influenced the development of almost every art and design movement. Perspective has also shaped the development of engineering and science from the earliest times in ancient thought to the Renaissance and modern times. And perspective has underpinned technology development and creative efforts. In New Media and communication systems, perspective theories and methods help make the underlying technologies possible. Understanding how light and other electromagnetic radiation propagate through space, together with the spatial geometry of lines of sight, transmitters, receivers, antennas and satellites, is fundamental to long-distance optical, radio and satellite communication. Perspective methods also enable the efficient *capture, linking, indexing, mixing, mapping, exploration, matching and cross-matching* of spatial views and images.

Henceforth, the highly serviceable types and methods of perspective are critical to progress. They provide new powers to visualise, model and create artistic, scientific and technological solutions to problems of unprecedented scale, scope, depth, context, detail and accuracy. Developments in perspective, dimensional modelling and mapping will profoundly shape human destiny.

Stages of Representation

Connecting
Ordering
Mimesis
Matching
Mixing
Exploring
Cross-Matching

Influences

Art
Science
Technology
Phantasy
Illusion

Optics
Drawing
Painting
Sculpture
Theatre
Scenography
Astronomy
Navigation
Architecture
Surveying
Map-Making

Engineering
Mathematics
Computing
Communications
Space Flight

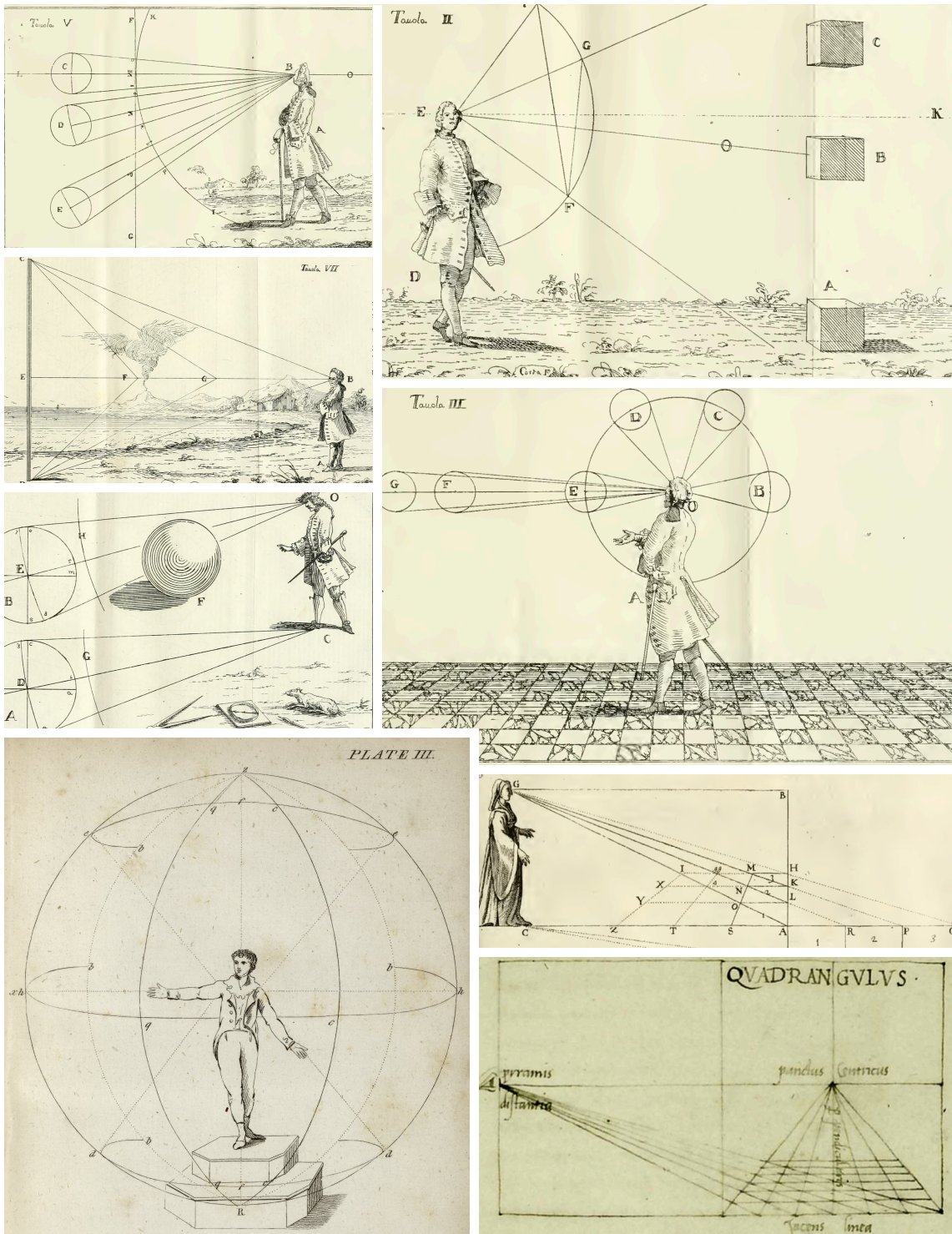


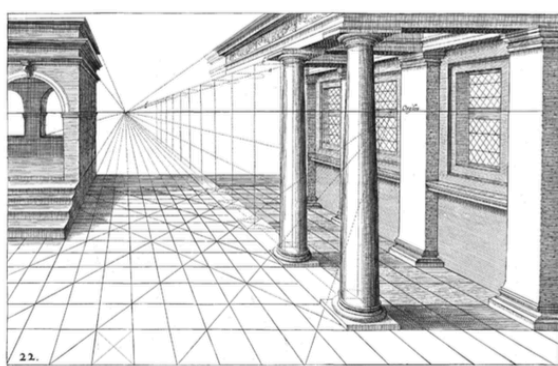
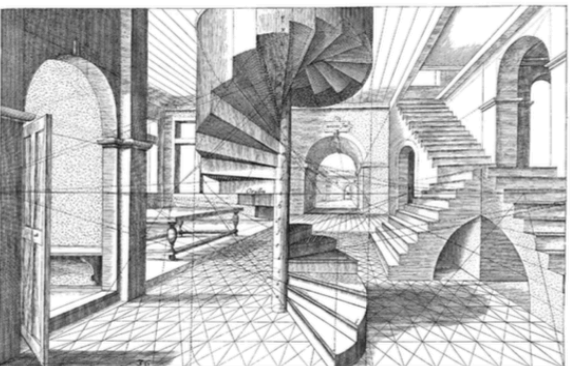
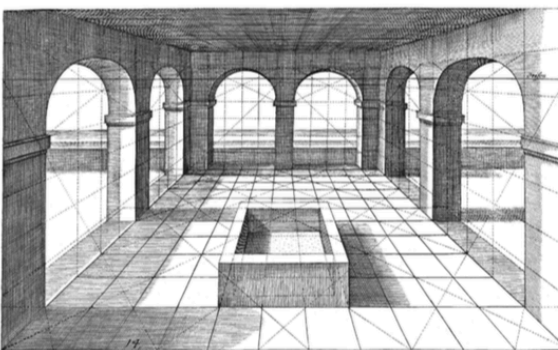
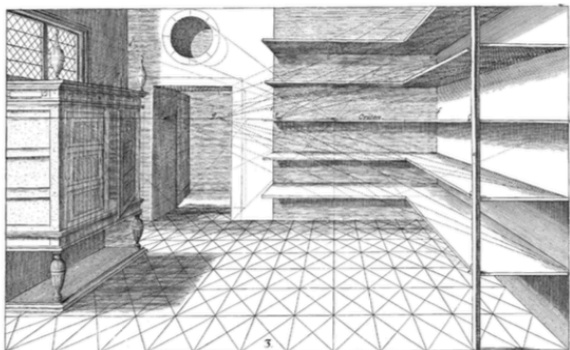
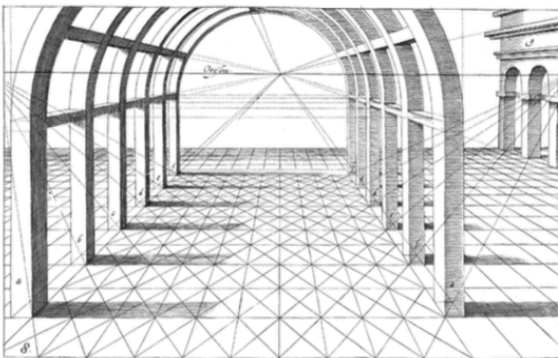
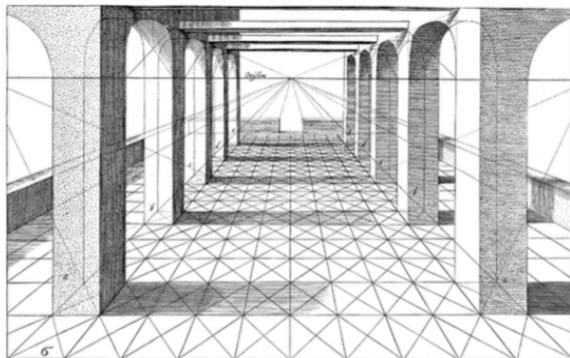
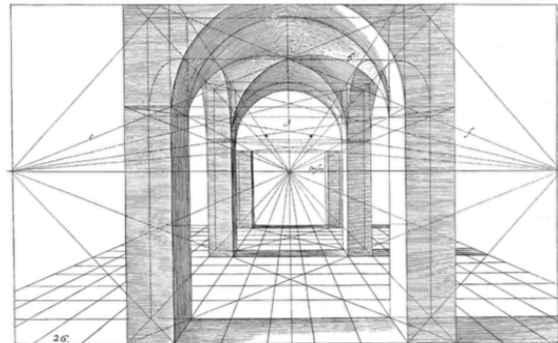
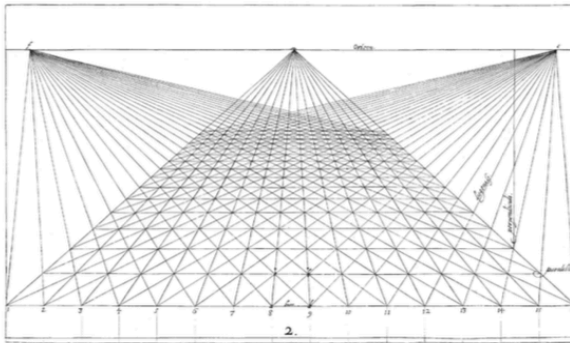
Figure 5: Visual / Graphical Perspective

Top and middle rows: plates from *Elementi di prospettiva per uso degli architetti e pittori* by Giovanni Francesco Costa, 1747.

Bottom left: Sphere-of-vision diagram, by Cage, c.1747.

Bottom right, upper: Graphical perspective after Vignola, 1583.

Bottom right, lower: Perspective diagram after Alberti, c.1450.



Linear-perspective drawings by Hans Vredeman de Vries, 1604.

Figure 6: Graphical / Mathematical Perspective

Perspectivist
 Perspective Views
 Perspective Images
 Perspective Drawings

In summary, perspective is a cross-disciplinary subject with both academic and practical dimensions. A subject discipline is a branch of study with an established theoretical background, research methods and groups of experts dedicated to understanding its principles, conducting research and teaching. Many years ago, a **perspectivist** referred to someone skilled in the art of making perspective views/images/drawings using correct or scientific principles. Arguably, and in this sense, today, we are all *perspectivists* who create, consume, or analyse perspective images and spatial views of one kind or another (on a daily basis). In sum, perspective qualifies as both an academic and practical subject discipline of unprecedented importance.

For some people, perspective is an established spatial representation technique primarily used in art. Ergo, one might suppose that the sources, principles, theory, and methods of perspective are well-understood today and that further research into perspective would not be necessary. However, this is not the case, as the wider field of visual and optical perspective contains many unexplained facts, perplexing mysteries, and exciting possibilities. Perspective is a fast-developing field with many modern application areas that are predicated on perspective-related research activity. In truth, much is unknown, and many questions remain unaddressed. Today, the field of perspective is positively brimming over with many new theories, methods, inventions, and vital application areas, and it continues to evolve at a rapid pace. Recent applications of perspective have spurred the rise of simulations, Virtual Reality, and the metaverse and other simulated environments, increasingly blended with representations of the physical world. The real and simulated worlds are now blended in our everyday experience.

Transformative
 Physical Orientation
 Mental Orientation

Perspective transforms our concepts of space, time, vision, and representation. It is key for both **physical and mental orientation**—and a tool for conceptual navigation, recording, and organisation of visual knowledge. Evidently, the principles, theory, types, methods, and applications of perspective are still being explored. And perspective has foundational links to almost every other subject discipline. Perspective is an old subject with an exciting future. No wonder that perspective, which introduced the concept of an open horizon, is such an open field. Perspective is often described as something mainly linked with the Renaissance, and as a practice that continued until the 19th century and then died out. Such is not the case because perspective has continued unabated to the present. Remarkable is how the pivotal subject of perspective can be key to a vast array of scientific and technological advances, yet be almost invisible, existing in an unconscious realm of the human mind/culture (collectively).

Can we identify an underlying cause for the perceived demise of perspective?

To begin, perspective rarely remained an entirely independent discipline and was frequently classified within optics, architecture, drawing or geometry and was subject to the vagaries of classification within four branches of learning: *optics, architecture, drawing, and geometry*. This had two significant consequences. First, classification changes, particularly in geometry, have shifted the definition of what constitutes perspective. In the 19th century, perspective included one, two, and three-point perspective, as well as various branches of parallel perspective. In the 20th century, the scope of the term was frequently restricted to one, two and three-point perspective, whereas all parallel versions are classed as projections. A central perspective projection is not merely a dilation. It is a projective mapping from a centre of projection to an image plane. Parallel lines not parallel to the picture plane may meet at vanishing points, whereas a simple dilation preserves parallelism.

A second consequence has been no less dramatic, because perspective has been classified as work in *optics, architecture, drawing, or geometry*. Kim Veltman's *Bibliography of Perspective* and *Encyclopedia of Perspective* have crossed these artificial disciplinary barriers, collecting hitherto disparate materials relating to perspective [10,13].

But if perspective is a distinct field, then to which subject class does it belong? Should we ascribe it as an art, science, or else a practical discipline?

Perspective is a **science**. But it is a science that involves multiple disciplines such as *physics (space/time), optics, geometry, vision, engineering drawing, mathematics, and computing, etc.* Each area consists of both theory and practice, and our new perspective science must take everything in its stride without missing a beat (unambiguously). Desired is all of the truth, logic, and hence predictive power of true science. Perspective is also an **art**. Patently, perspective, being concerned with appearance and representation, has had a strong influence on all aspects of the *visual and graphic arts, the plastic arts, the decorative arts, the performing arts, and architecture*. Perspective is also a **technology**. Optical, matching, and surveying instruments enable us to probe physical reality and obtain accurate views, images, measurements, and models. Perspective technology has been essential for the development of *photography, cinema, television, computer-aided design, virtual reality, and robotics, etc.*

Perspective has no single disciplinary nature. It concerns viewing, forming, projecting, measuring, modelling, matching, representing and simulating spatial reality and its resulting images, views and appearances. Wherever spatial forms are viewed or represented, perspective is involved; it cannot be confined to one established discipline.

Art

Visual Arts
Graphic Arts
Plastic Arts
Decorative Arts
Scenic Arts
Performing Arts
Architecture

Science

Physics
Space / Time
Optics
Geometry
Vision
Engineering
Drawing
Mathematics
Computing

Technology

Optical Instruments
Matching Instruments
Surveying Instruments
Photography
Cinema
Television
Computer-Aided Design
Virtual Reality
Robotics
Computer Vision
Space Flight

Perspective stands alone, yet its chameleon-like nature directly or indirectly influences every other subject discipline! Patently, it is time for a new approach to art/science/technology that encompasses and benefits from a deep understanding of perspective. There is a need to establish perspective as a primary branch of knowledge, enabling the coherent development of subject matter, disseminating an improved understanding of basic principles/theory/methods, and fostering fundamental progress in this key area. But there is another compelling reason why perspective knowledge must be gathered and combined into a unifying subject framework, and this relates to a well-known cultural dilemma.

Perhaps one of the biggest blockages to progress is cultural, as explained by Sir C.P. Snow [1905–1980] in his 1959 book *‘The Two Cultures and the Scientific Revolution’* [11]. Snow argued that science and the humanities had become divided into ‘two cultures’, and that this division was a major handicap in addressing the world’s problems. If Snow is correct—and substantial evidence suggests that he is—then our call to establish a separate subject discipline for perspective is also correct, especially given the tremendous number of relationships and interrelations of perspective knowledge across art, science, and technology.

Perspective is a special case in this respect, because it is intricately embedded in all of the various sub-disciplines of each subject (in innumerable ways); and it is difficult to find any visual/imaging/representation topic that is not ‘perspectival’ in one way or another. Perspective is such a fundamental and profoundly influential field that it should be taught as a distinct discipline in schools, colleges, and universities. Perspective is the very definition of a cross-disciplinary or interdisciplinary academic field, with countless sources, links, and foundational concepts/relations penetrating to the core of key phenomena in the arts, sciences, culture, and technology.

In the 20th century, perspective re-evaluated the principle of object/image correspondence, challenging its ideas by reversing transparency-opacity laws and the concepts of windows and walls. These experiments expanded the categories of correspondence to include theoretical, assumed, possible, transposed, and no direct correspondence. Experiments with alternative picture planes and New Media boosted this trend. Transformations followed between visual systems/methods.

In art, perspective led to new visual methods and forms of exploration; in science/engineering, it raised questions of truth; and in illusion, questions of real/unreal. Scientific or linear perspective (graphical form) was a method for clearly demonstrating relationships between representations and their target objects, revealing the optical and geometrical/mathematical foundations of both.

Cross-Disciplinary
Axioms / Principles
Foundational Theory
Sources / Links
Concepts / Relations

Art
Exploring
New Visual Methods
**Science /
Engineering**
Truth / Falsehood
Illusion
Real / Unreal

By contrast, perspective in the 20th century became a process of hiding its sources, veiling its connections with the linear perspective original, altering the principle of object/image correspondence, shifting, transforming, and denying it until it was impossible to see the source. Some have linked today's unrestricted representation capability with freedom, as proof that the spirit is not bounded, or limited by a one-to-one link with the physical world. Others have avoided the notion of correspondence, as if one could make the outside world go away, only to find themselves troubled by questions of difference, the other, and the similar [10,14,15].

Overall, there is a modern trend towards finding new ways of relating to physical reality, with an emphasis on context and re-contextualisation. In the process, perspective is found to be something more fundamental/profound than a convention, visual illusion, or a temporary fad. Philosopher Immanuel Kant [1724–1804] recognised that perspective is key for **spatial orientation**. But on the other hand, perspective is also a tool for conceptual navigation: a way of finding *where we are*, and discovering *who, what, how, and even why we are*.

How then can we adequately define perspective?

A good starting definition in the context of graphic art (pictorial/scenic forms) reads as follows:

The term 'perspective' may refer to any graphic method, geometrical or otherwise, that is concerned with conveying an impression of spatial extension into depth, whether on a flat surface or with form shallower than that represented. Perspective composition results when the artist adopts a visual approach to drawing and consequently portrays perspective phenomena such as the diminution of object size at a distance and the convergence of parallel lines in recession from the eye.

Etymology studies word origins, tracing their development, changes in meaning, and formation through borrowing and language evolution. In terms of etymology, the English word perspective derives from the Latin *perspectiva*, a complex term with a long history of diverse interpretations. Indeed, the confusion persists today because perspective means different things to different people (and in different contexts)! 'Perspectiva', says Albrecht Dürer [1471–1528], 'is a Latin word and means "Durchsehung": a view through something [space]'. But *perspectiva* also refers to *perspicere* in looking directly at something or seeing 'a form clearly' with your eyes [ref. visual aspect].

Remember also that, in our terms, perspective may involve viewing or imaging, projecting, measuring, matching, modelling, representing, or producing an illusion or immersion in spatial reality.

20th Century

Tendency to Avoid / Ignore Linear Perspective

New Belief of No Direct Correspondence Between Object / Image

Re-Contextualisation of Physical Reality

Spatial Orientation
Visual Maps / Models
Conceptual Navigation

In the fifteenth century, perspective also became associated with scenography and with graphical methods for representing spatial objects and scenes on two-dimensional surfaces. The term has nevertheless retained several historical meanings. These cannot be reduced simply to a division between natural and artificial perspective. In the revised framework used here, the principal categories include Natural, Visual, Optical, Mathematical, Graphical, Instrument, Simulated and New Media Perspective; Visual Perspective Type 2 is the human retinal and perceptual subclass of the broader Visual Perspective Type 1.

Today, perspective in one form or another remains central to vision, spatial modelling and the creation of appearances. Several perspective categories may operate simultaneously, making it difficult to isolate the source of a particular visual effect. Environmental optical effects and Visual Perspective Type 2, for example, may jointly shape a person's experience of a scene. This complexity can be addressed by distinguishing perspective categories, directional classes, types and forms, identifying their characteristic features and determining the circumstances in which they operate. A single narrow definition cannot encompass the many ways perspective has been employed in vision, mathematics, art, instruments and computing.

A little over 2,000 years ago, the ancient Greeks developed some of the earliest systematic attempts at a realistic depiction of depth on a flat 2-D surface, employing key perspective phenomena. These phenomena include apparent **diminution of size** with distance (size/distance formula), apparent **diminution of form** (loss of outline detail with distance), apparent **degradation of form** (object shape distortions with viewing angle), **aspect foreshortening** (viewing direction apparent contraction of size), plus **vanishing points**, among others. However, they are not generally considered to have developed, understood or applied a fully codified method equivalent to Renaissance linear perspective. Such a method assumes a fixed viewpoint: each family of parallel lines receding in a particular spatial direction converges towards its own vanishing point, while lines parallel to the picture plane do not converge.

The development of Renaissance linear perspective drew upon several traditions, including ancient Greek geometry and optics, Roman scenography, medieval European painting and architecture, and optical scholarship transmitted and extended in the Islamic world. India, China and Japan developed their own sophisticated systems of spatial representation, which should not be judged simply as incomplete forms of European linear perspective.

N.B. Foreshortening is when an object or scene's dimensions aligned along the depth direction are contracted in apparent size relative to dimensions in the orthogonal direction. A common misconception is that there is only one type of foreshortening, but in fact we have two types that often interrelate. There is **aspect foreshortening** based on projection angle, and **perspectival foreshortening** based on apparent size diminution with depth.

Perspective is Key to Visual Topics

Vision
Spatial Modelling
Creating
Appearances

Perspective Phenomena

Diminution of Size
Diminution of Form
Degradation of Form
Aspect
Foreshortening
Vanishing Points
++ more

Whilst perspective has foundations deeply rooted in the past, it remains a distinctly modern subject. Nevertheless, older principles, theories and perspective methods remain highly relevant to the contemporary world and its myriad of visual technologies. Indeed, the budding perspectivist has much to gain from a close study of the history of perspective.

The *Oxford English Dictionary*, second edition, defines perspective as follows:

- The science of sight; optics.
- An optical instrument for looking through or viewing objects with; a spy-glass, magnifying-glass, telescope, etc.
- The art of delineating solid objects upon a plane surface so that the drawing produces the same impression of apparent relative positions and magnitudes, or of distance, as do the actual objects when viewed from a particular point.
- The appearance presented by visible objects, in regard to relative position, apparent distance, etc.
- The relation or proportion in which the parts of a subject are viewed by the mind; the aspect of a matter or object of thought, as perceived from a particular mental 'point of view'. Hence the point of view itself; a way of regarding (something).
- A drawing or picture in perspective; a 'view'; a picture so contrived as seemingly to enlarge or extend the actual space, as in a stage scene, or to give the effect of distance.
- A picture or figure constructed so as to produce some fantastic effect; e.g. appearing distorted or confused except from one particular point of view, or presenting totally different aspects from different points.
- A visible scene; a (real) view or prospect; esp. one extending in length away from the spectator and thus showing distance, a vista.
- A mental view, outlook, or prospect, esp. through an imagined extent of time, past or (usually) future; hence sometimes = expectation, 'look-out'.
- Drawn or viewed in accordance with the rules or principles of perspective.
- The action of looking into something, close inspection; the faculty of seeing into a thing.

Upon reading such varied and sometimes contrasting definitions, we are once again struck by the chameleon-like nature of perspective. It is linked with optics, vision and point of view; the third dimension or depth; appearance; drawing and painting; illusion; and even mental outlook, *etc.* Indeed, it would be difficult to find a subject discipline, whether artistic, scientific, technological or cultural, that has not been strongly influenced by, if not actually rests upon, perspective principles/theories/methods of one kind or another.

Patently, perspective is a multifaceted term that can portray—or instantiate—various meanings/uses!

Modern Subject

Perspective is by no means an old, abandoned, or dead subject. On the contrary, today, we see more types and applications of perspective than ever before.



Pseudo-perspective from the *Bedford Hours*, a French medieval manuscript, c. 1410–30.

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