The need for design

Exploring Dutch landscape architecture

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New tools
Digital media in landscape architecture

Landscape architects use analogue and digital media to understand and design urban areas and the countryside. Because new media in particular enable us to use different approaches to thinking and communicating about spatial design issues, they are contributing to the development of the field. Steffen Nijhuis explains where digital media belong as part of a long tradition and examines the ways in which they can be used.

Visual representations such as maps, drawings or models, but also text and still or moving pictures, form the basis of research and design in landscape architecture.[1] Over the last few decades, these methods have been complemented by digital media, otherwise known as new media.[2] These involve communicating information or knowledge through speech, pictures, text and sound with the help of digital technology. Examples are computers, the Internet, virtual 3D landscapes, digital video and photography, computer graphics (Fig. 1), geographical information systems (GIS), computer simulations, computer-aided drafting (CAD), virtual reality and mobile telephony. Social media are also digital media – online platforms where users provide and manage the content, such as blogs, webfora and social networks.

How are digital media used in the daily work of landscape architecture? What opportunities do they offer for research and design?

Retrospective

The use of models, drawings and maps goes back far into the past.[3] In around 2000 BC, maps of villages were carved into the rocks of northern Italy. In Egypt and China, ground plans and models have been found that are even older.[4] According to the Roman architect, Vitruvius, a ground plan, section and perspective were essential for achieving a good design. From the 14th century, visual representation became increasingly important, influenced by developments in measuring techniques and the visual arts, and by the growing professionalism of the disciplines engaged in spatial design.[5] The making of models, ground plans, perspective drawings and maps became increasingly established as a means of analysing and designing – and communicating about – existing and future spatial situations.

In the 18th century, landscape architects first began experimenting with painted 'moving' pictures. French landscape designer Louis Carmontelle painted extensive imaginary landscape panoramas onto long bands of paper. These were wound onto two wooden rollers and, using an ingenious instrument, unwound like a video, lit from behind.[6] The 'before and after' drawings of English landscape designer Humphry Repton are world-renowned and were intended to give clients an impression of how a landscape would look after work was completed (Fig. 2).[7]

In addition to this development in presentation techniques, instruments were invented which supported spatial investigation and design. One example is the perspectograph, invented by mathematician Johann Heinrich Lambert in the 18th century. This instrument translated ground plans into perspective drawings (Fig. 3). In this period, engineer and geographer Jean-Marie Morel developed systems of notation to link knowledge of nature and landscape – tree species, types of water and geomorphology – to landscape design. In 1804 Morel used the term landscape architect – *architecte-paysagiste* – for the first time.[8]

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1 Digital painting with image processing software. Artist's impression from the landscaping and management plan for the Drentse Ballooërveld, the Netherlands. (Source: Strootman Landschapsarchitecten, 2010)

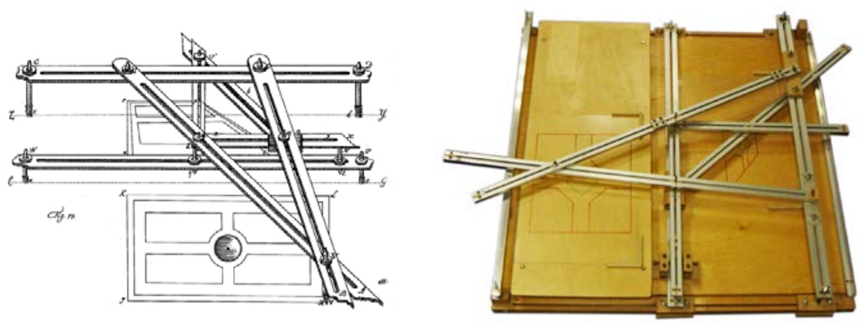
2 The English landscape designer, Humphry Repton, made 'before and after drawings' for his clients, which he published in his world-renowned Red Books. Opening a drawing of the existing situation on both sides revealed the interventions he proposed for the place in question. Pictured is the 1793 design proposal for the Purley estate in the county of Berkshire, with the existing situation (left) and the design for the future. (Source: Rogger, 2007, note 7)

3 Johann Heinrich Lambert invented the perspectograph in the 18th century. It could be used to convert a ground plan into a perspective drawing. Left: the original design for the perspectograph from the book *Anlage zur Perspektive* (1752). Right: a modern reconstruction of the instrument. (Source: Laboratory of Mathematics, University of Modena and Regio Emilia)

4 Carl Steinitz was a pioneer who used geographical information systems (GIS) for landscape research and planning. The map shows an automated analysis of the visual character of the landscape in the Boston area. (Source: Steinitz and Rogers, 1970, note 15)

Photography entered the scene at the end of the 19th century. This made it possible to take photographs of a spatial situation from specific viewpoints and then to manipulate them. After World War II, the use of aerial photographs and stereophotography made it possible to analyse and map large areas.[9] Later, satellite photography and remote sensing were added, allowing very precise recordings of the Earth's surface. For example, for landscape research Cornelis von Frijtag Drabbe used interpretations of aerial photographs to create maps known as 'red-blue or wet area maps'. On these maps it could be seen which parts of a landscape were wetter or drier at times of bad drainage and flooding.[10]

The arrival of electricity early in the 20th century enabled the development of an overlay technique in which light tables played a crucial role. Several drawings could be overlayed in order to analyse spatial relationships, for example between soil structure and vegetation. Warren Manning was one of the first landscape architects to apply this technique when he used it for his urban development plan for the town of Billerica in Massachusetts.[11] Jan Bijhouwer, the first Dutch professor of landscape architecture, used the overlay technique in his plantation scheme for the Wieringermeerpolder in North Holland and the extension and park plan for Kethel, near Schiedam in the province of South Holland.[12] Later, this method was further developed by Ian McHarg[13] and had a major impact on the development of GIS and Dutch system-thinking about landscape.[14]



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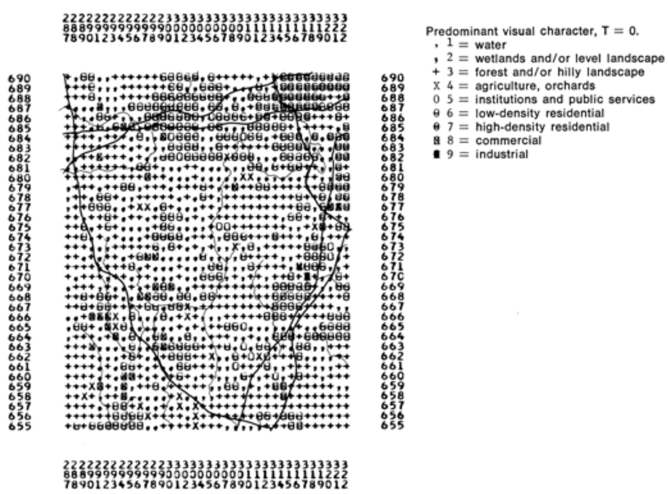

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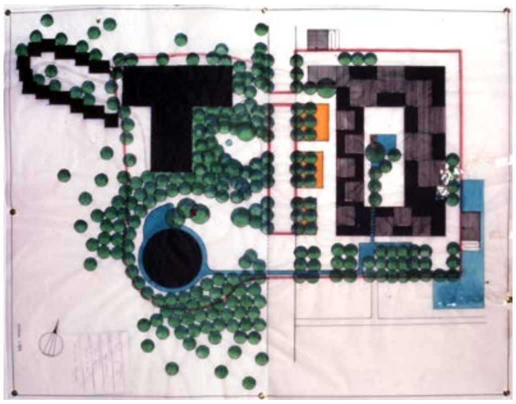

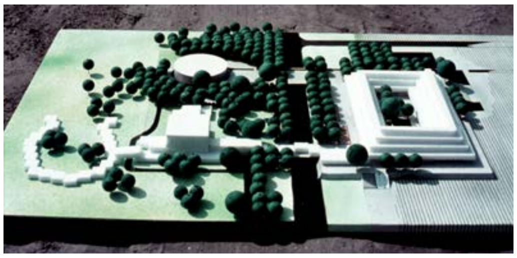

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5 Since the 1970s, the enthescope has been used to provide insight into the spatial quality of a design. For the design of a town centre, an enthescope is fixed to a camera lens and the camera is placed vertically inside the model in order to take photographs or moving pictures. (Source: Michiel den Ruijter, 1971)
6 An early experiment with CAD and 3D modelling: the design for the 1992 Floriade (international flower and garden exhibition held in the Netherlands every 10 years) in Zoetermeer is constructed in three dimensions in a digital environment and mounted on an aerial photograph of the existing situation. (Source: Michiel den Ruijter, Janneke Roos-Klein Lankhorst and Joost Koek, University of Wageningen, 1984)

The digital era

Since the 1950s, people have worked increasingly with computers – first with mainframes and later with PCs. Early experiments using computer-generated maps, databases and digital overlay techniques were carried out from 1967 onwards by Carl Steinitz of Harvard University.[15] Previously, in Canada, Roger Tomlinson had introduced the term geographical information systems (GIS) for such computer applications.[16] The simultaneous development of the first dot matrix printers offered the possibility of printing the results of analyses and using them in landscape planning and design (Fig. 4). Video was also used to create and play moving pictures, in order to analyse developments over time. The same period saw the development of computer-aided drafting (CAD). Drawings and virtual 3D landscapes could be constructed in a digital environment. This technique depended on the pen plotter, which was essential for printing line drawings onto paper. Because the development of the pen plotter was slow, CAD use took time to get going.

Starting in the 1970s, the first experiments were done with the enthescope, a camera with a periscope lens. This is used for moving through models, to take photographs or moving pictures in support of the analysis and presentation of urban design and landscape architecture ensembles (Fig. 5).[17] The digital revolution only really got going in the 1980s, because personal computers became more widely available. Increasingly, companies began to depend on computers and digital technology. In landscape architecture, CAD, virtual 3D landscapes (Fig. 6) and GIS became increasingly important for research and design, first at research institutes and later at landscape architecture practices. From the early 1990s, digital image processing came into use.[18] Since that time, being able to work with digital media has been one of the basic skills of the landscape architect.

The last 25 years have been characterised by a rapid transition from analogue to digital media. The arrival of image-processing software, 3D modelling, CAD, GIS and computer-aided manufacturing (CAM) – where machines controlled by computers manufacture components – has changed the way in which analogue maps, drawings and models are used. Digital multimedia presentations with text, still and moving images, and sound are becoming increasingly important for transferring ideas and providing clear and concise information to stakeholders. Mobile devices and the Internet are becoming ever more interconnected, and social networking has grown to be a standard way of communicating.

Digital interfaces and operations

There is no doubt that digital media are important for landscape research and design. They are 'vehicles' for thinking and communicating at various levels. They are not only

INTERFACES

- Computers and peripheral devices: screen, mouse, digital pen, keyboard, webcam, smart board, wii
- World Wide Web, Internet
- Mobile telephony and personal assistants: gsm, smart phones, tablets, notebooks
- Digital cameras: video and photography
- Position tracking: global positioning systems (GPS)
- Tangible user interfaces and multi-touch interaction tables: multi-touch table, luminous table, Illuminating clay, Sandscape, Sensetable
- Virtual environments, head-mounted displays and simulation laboratories: CAVE, Simlab
- Multimedia meeting rooms and group decision rooms

OPERATIONS

- Digital word processing, spreadsheets and databases
- Image processing and desktop publishing
- Virtual 3D landscapes: 3D modelling, virtual reality (VR)
- Software platforms: computer-aided drawing (CAD), geographical information systems (GIS), building information model (BIM), decision support systems (DSS)
- Location-based services: geotagging, geocaching, augmented reality markers (AR-markers), points of interest based on GPS (POIs)
- Computer simulation or models (deterministic or stochastic):
  - Geocomputation: computer games (serious gaming), time-geographic models, traffic and transport models, planning models, economic models, morphology and visibility models, cognitive models, multi-actor models, building technology and logistical models, hydraulic engineering models, nature and environmental models, agricultural models, energy models, ecological models[20]
  - Computational form generation: coding, scripting, genetic algorithms
- Computer-aided manufacturing (CAM) and rapid prototyping: 3D printing, CNC milling, laser cutting
- Augmented reality (AR)
- Web applications and social media: online maps and aerial photographs, search engines, panoramic photographs, quick response codes (QR codes), weblogs, webfora, social networks (profile sites, blogging, visual media sharing, wikis)

Overview of interfaces and operations.

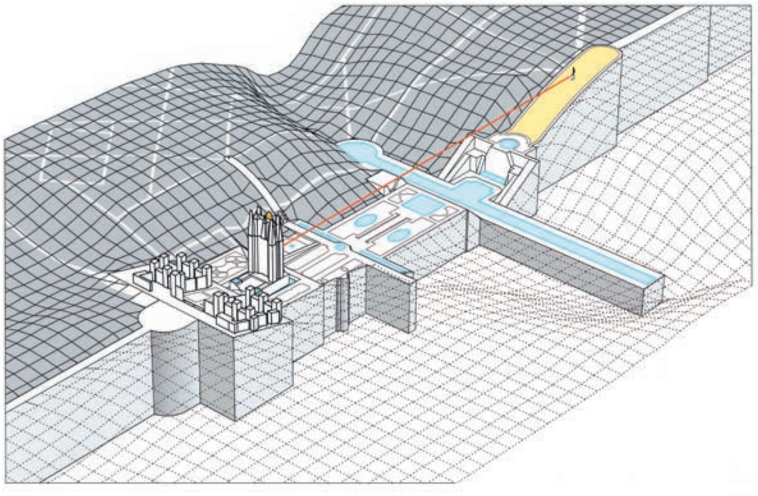
handy for transferring information and for understanding and representing a current or future reality, but also for recording, analysing, manipulating and expressing ideas, shapes and relationships. In connection with digital media, we often talk about a visual culture dominated by computer graphics, maps, virtual 3D landscapes and computer animation. This fits seamlessly with the visual culture of landscape architecture, where visual representations play a key role in visual thinking and communication. Visual thinking implies generating knowledge and ideas by creating, inspecting and interpreting visual representations of what was previously not visible, while visual communication refers to the effective transfer of ideas in visual form.[19]

In order to understand the use of digital media in landscape architecture, it is helpful to distinguish between the concepts 'interface' and 'operation'. Interface means the relationship between human and computer – the technical system. Operation means the actions that are performed. The table shows the most important interfaces and operations, most of which are explained in the text. The distinction between interface and operation is often not clear, because digital media are characterised by a combination of the two. Media use ranges from general applications, such as word processing, communication and marketing, to specific applications such as advanced spatial research and virtual 3D landscapes.

In landscape architecture we can distinguish three areas of application: research, design, and presentation and communication. In the first two, the emphasis is on thinking and reflecting, while the third focuses on the effective transfer of specific information and knowledge. Deliberating, processing, documenting, learning, constructing, testing, associating, speaking for and working within groups are all activities for which people use digital media.

Applications in research

Research concerns analysing and evaluating situations, designs or precedents. Its aim is to clarify how something works in a physical, biological or cultural sense, or which spatial or other organising principles are used. Structures, patterns, processes and their relationships in space and time are depicted. Linking certain elements or aspects of a landscape through overlay drawings can bring about an understanding of the relationships between cultural patterns – construction, roads, land parcellation, etc. – and the natural system of soil, geomorphology and hydrology. Architectonic features such as form, space, organisation, proportion and scale can be investigated using reduction or analytical drawings (Fig. 7).[21] By using suggestive cartography, datascaping and statistical landscapes, we can combine or spatially interpret data, aerial photographs, thematic maps and diagrams in order to read a landscape in an alternative way and recognise relationships.[22]



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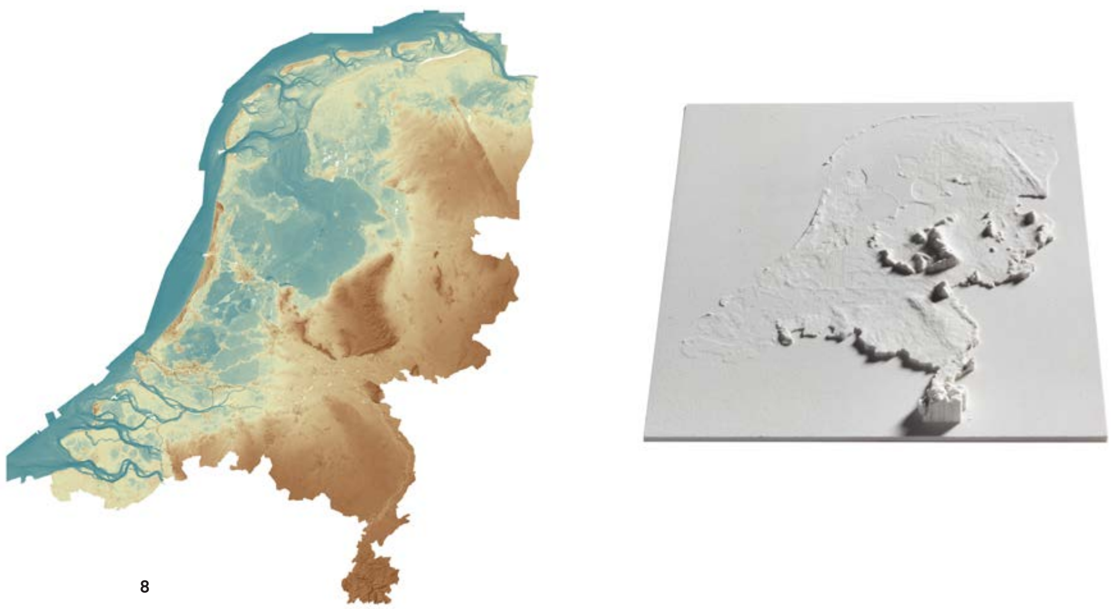

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7 Analysis drawing of the French garden Vaux-le-Vicomte in Melun, produced with the help of CAD and image processing software. The spatial construction and orientation of the design is investigated by drawing elements of the composition and linking them together. This reveals how the natural height differences are used to make a longitudinal axis, which creates an illusion of infinity. The axis provides a geometrical horizon, which is marked by a statue of Hercules. (Source: Steenbergen et al., 2008, note 21)

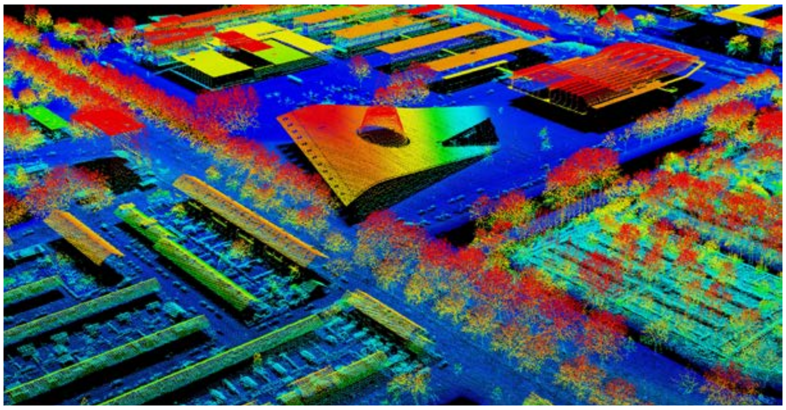
8 GIS-based computation of data on altitudes in the Netherlands. The precise data can be visualised in various ways. As a map (left), where the colours represent the altitude in relation to sea level. A shadow cast in the background makes altitude differences clearly visible. Areas below sea level are blue and those above sea level are brown; or as a 3D print, in which the altitude data from GIS are translated by a 3D printer into a model – with a scale of 1 to 500,000 and the height exaggerated a hundredfold. (Source: Steffen Nijhuis, TU Delft, 2011)

In this search, digital media such as CAD, GIS, 3D modelling and image-processing software function as an 'extension of the hands', where a pen and pencil are replaced by a mouse and digital drawing pen. This allows analytical and graphic operations to be carried out more precisely and more quickly, and it is possible to work with large amounts of information.

Using the calculating power of computers, combined with inventive analysis, modelling and visualisation techniques, creates new information and knowledge about spatial construction, processes and use. In this context, digital media can be seen as an 'extension of the brain', as tools for supporting observation and reflection.[23] It is especially GIS and computer simulations, in combination with 3D modelling, which offer usable applications in this respect. GIS and computer simulations are powerful instruments for grasping complex situations in the present, the past or the future, through the integration of computer applications such as image processing, CAD, cartography, data modelling and database management. Against this background, research institutes are developing applications for spatial design in the areas of data acquisition, modelling, analysis and visualisation. One example comprises the three-dimensional geometrical data from objects and areas which are obtained from the air or from fixed positions, using laser scanners. This information can form the basis for precise models that show height differences in the landscape (Fig. 8), or the three-dimensional shape of the built environment (Fig. 9). A GIS-based analysis of the visual space using what are called visibility models is also a useful application for examining what users can see in an existing or future situation (Fig. 10).[24] Finally, there are ecological models that realistically depict the spatial distribution and expression of ecosystems through the construction of virtual 3D landscapes (Fig. 11).

The Internet provides an understanding of location, use and evaluation. As well as online vector- and grid-oriented maps, other web applications are also useful, such as online 360-degree panoramic photographs. With crowd sourcing – making use of a large group of individuals – techniques such as visual media sharing (Fig. 12) or specific apps (Fig. 13) can be employed to gain an impression of how landscapes are valued and used.

Another application for spatial research is position tracking. By providing selected groups of people with GPS devices (Fig. 14), or by exploring patterns of mobile phone use, it is possible to analyse and visualise people's flows of movement and patterns of stay in terms of duration.[25] This can underpin design interventions or management measures in towns and parks. It gives insight into the behaviour, orientation and movement of people in the environment, known as wayfinding. Experiments using digital photographs and video show the potential of moving pictures as a research tool in the fields of landscape perception or landscape phenomenology.[26]



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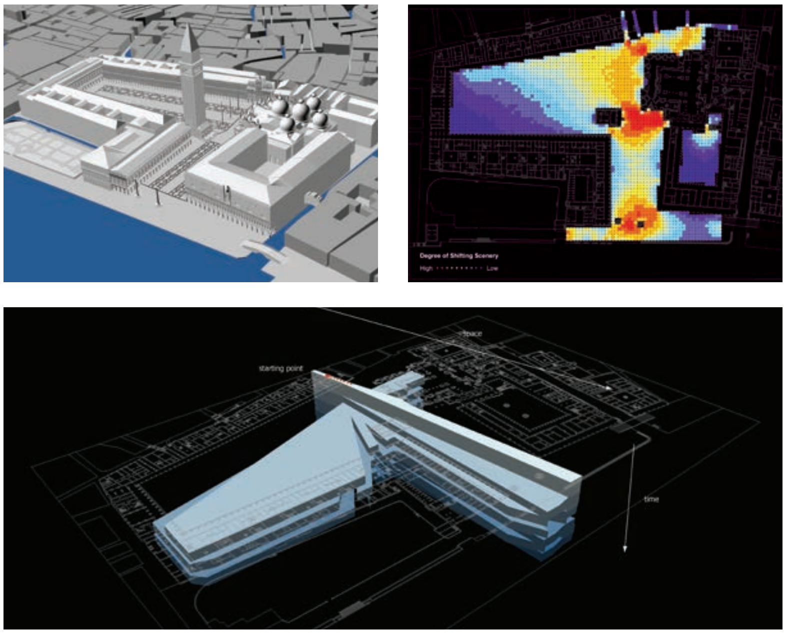

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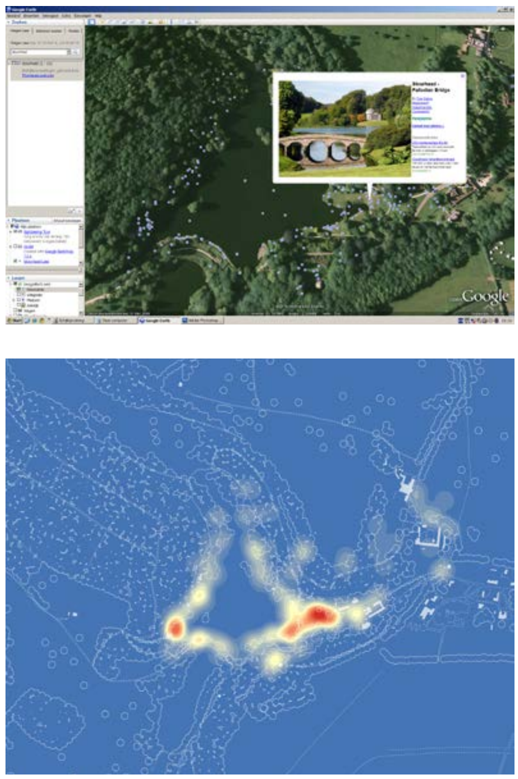

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9 3D visualisation of part of the TU Delft campus, obtained from the air using laser scanners. The image contains millions of measuring points which could only be visualised with specialised software. The library and the auditorium are clearly recognisable. (Source: Michiel Pouderoijen and Addie Ritter, TU Delft, 2011)

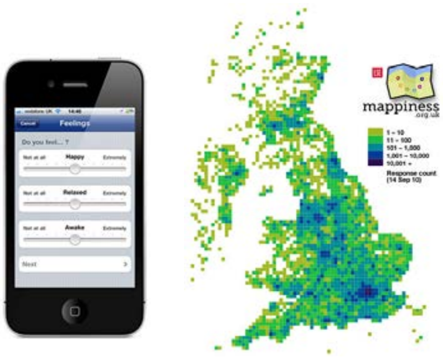
10 Investigation of the spatial construction of Saint Mark's Square in Venice. Above left: a precisely constructed 3D model enables researchers to study and visualise the spatial construction from various viewpoints – at eye level or a bird's-eye view. Above right: a GIS-based visibility analysis shows the variation that occurs in the field of vision – the extent to which the scene shifts at eye level. The red-orange-yellow colour range allows one to see a gradual spatial progression at the transition from one square to the other, with the clock tower as 'hinge'. Below: analysis in which successive fields of vision are calculated from the entrance to the square. Known as a Minkowski model, it shows from top to bottom how the square 'unfolds' – from a tightly framed view of the water to a view of the entire square. (Source: Steffen Nijhuis, TU Delft, 2011)

11 The spatial distribution and expression of ecosystems is depicted through a combination of GIS, models of planting physiology and real-time rendering. It is possible to move through such a virtual 3D landscape and to visualise how it functions from an ecological and spatial point of view. Through its linking of information, for example about soil composition and plant communities, it is a spatial database for research, development and conservation. Pictured is a simulation of alpine plant communities in the UNESCO biosphere reserve Entlebuch in Switzerland. (Source: Philip Paar, Wieland Röhricht, Olaf Schroth and Ulrike Wissen, Lenné3D & ETH Zürich, 2004)

12 Crowd sourcing makes use of visual media sharing. By analysing the distribution and density of online geotagged photographs (photographs with GPS coordinates), it is make clear which areas of the British estate Stourhead are most appreciated by visitors. Above: screenshot with the locations of online geotagged photographs. (Source: Google maps-Panoramio) Below: GIS analysis of the distribution and density of photographs based on quantity and distance. The red areas are where the most photographs were taken, which is an indicator for appreciation. (Source: Steffen Nijhuis, TU Delft, 2012)

13 Crowd sourcing using an app with which users answer questions about their experience and appreciation of the landscape. The answers are displayed through automatic position tracking. The result is, for example, a map of valued landscapes in England. (Source: mappiness.org.uk)

14 Movement patterns of a few dozen tourists in the French city of Rouen, obtained by supplying them with a mobile GPS device. Displaying the individual tracklogs on a map makes it possible to see the spatial orientation, intensity of use and distribution of a specific group of pedestrians in the city. (Source: Steffen Nijhuis and Stefan van der Spek, TU Delft, 2008)



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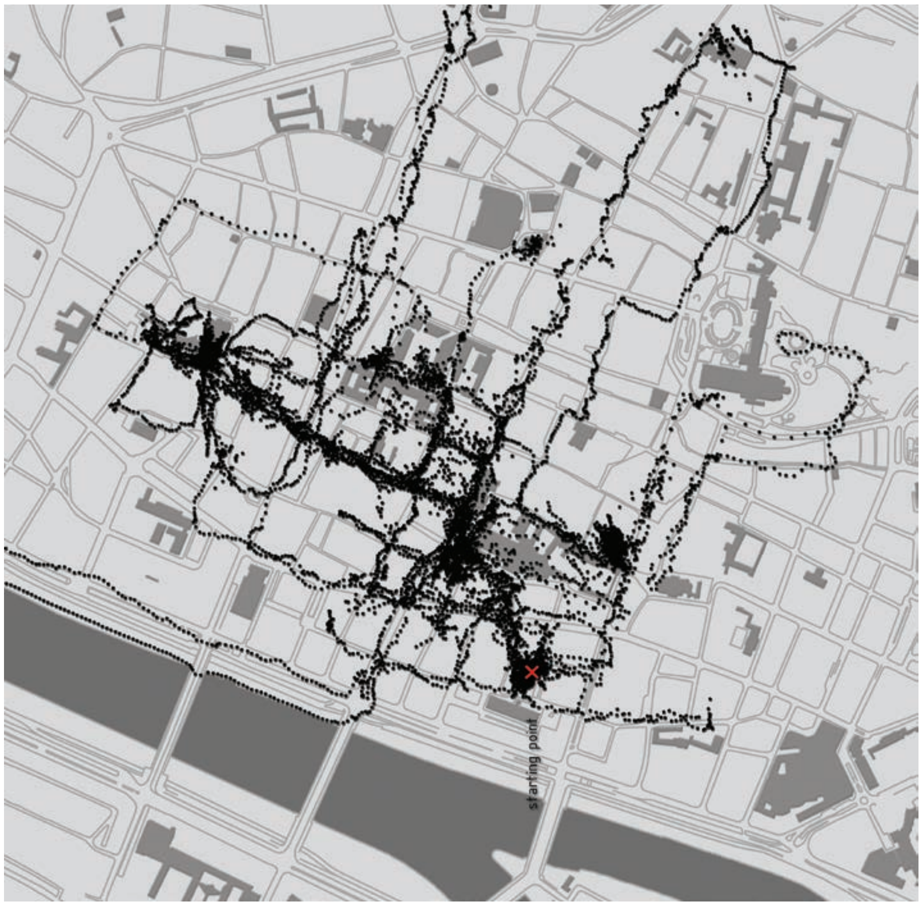

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Applications in design

Design involves exploring possibilities and synthesising knowledge and information at various levels of scale. Digital media play a supporting role in an iterative thinking process. Creation, development and testing alternate in order to arrive at a spatial design. In the creation cycle, the designer's initial ideas are given tangible form. This rudimentary design is then elaborated in a development cycle to achieve greater coherence, completeness and specificity. The test cycle is the moment of truth, when the design is tested against the criteria and standards set by the designer.

CAD and image processing software are frequently-used tools for creating and improving design drawings, views and perspectives.[27] 'Digital painting' with photographs and collages helps in shaping and representing creative ideas. With 3D modelling, a landscape can be designed in three dimensions, where the spatial relationships and effects are constructed from an eye-level perspective, and where movement also has a big role to play. The visualisation can be more or less realistic, depending on the intention and the time available.

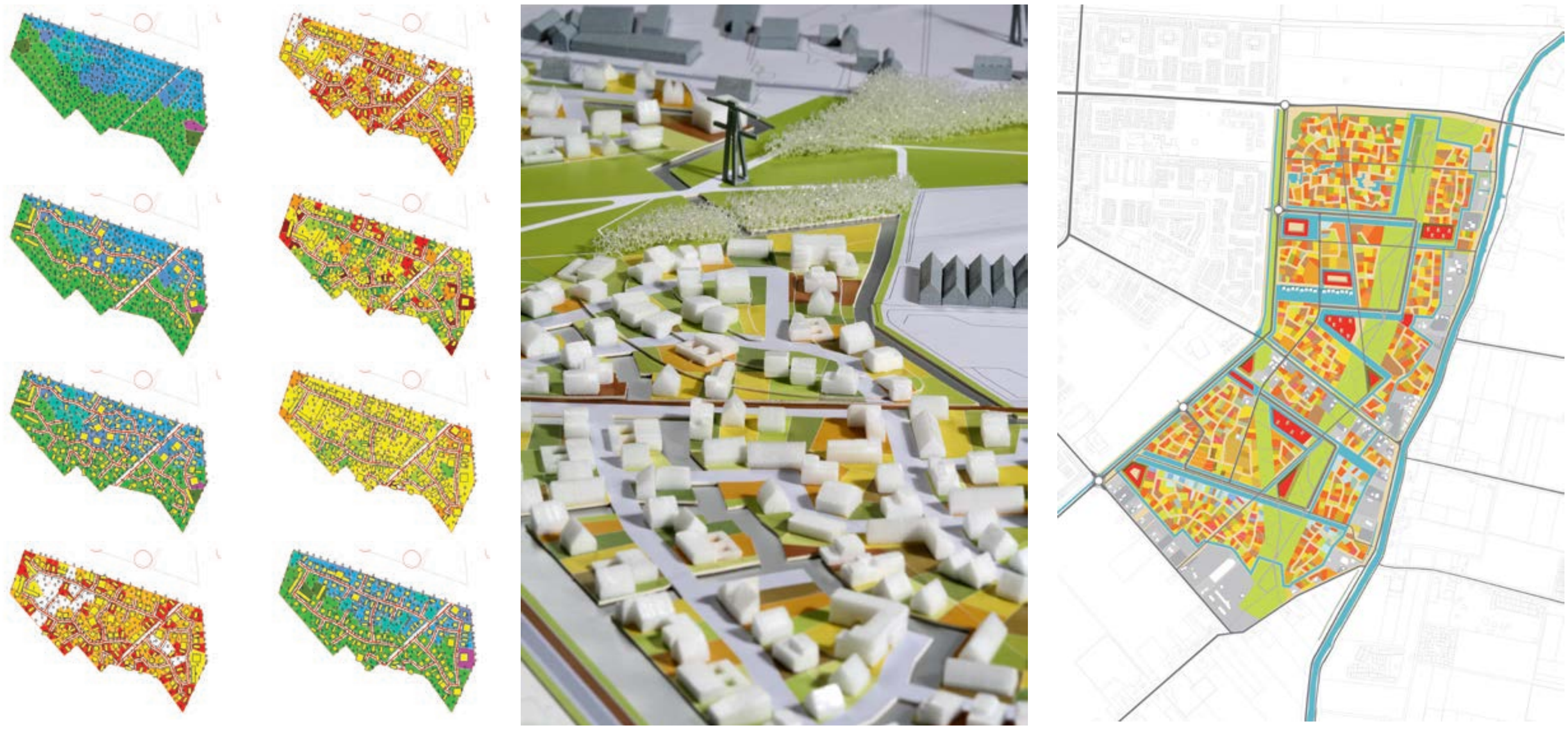
Computer simulations with computer games and morphological models provide input early in the design stage for possible spatial configurations. The designer lays down rules that form the basis of the design, for example concerning plot size, distance, infrastructure and greenery, while the model translates these into spatial configurations by means of statistical optimisation (Fig. 15).[28] Planning models make representations of possible spatial scenarios as a basis for regional planning and design.[29] The consequences of socioeconomic, climate and environmental changes are converted into possible spatial claims which serve as a schedule of requirements. Parametric design with the help of scripting or genetic algorithms can be used to generate three-dimensional shapes, objects or landscapes that comply with specific rules, technical or otherwise. This usually produces unexpected patterns, shapes or landscapes, which are used for association, as an elaboration of an idea (Fig. 16) or as direct input for actual projects.[30]

GIS is a powerful instrument for spatial design at various scales. Geodesign is a GIS-based approach in which location-specific and other layers of information are combined in space and processed to produce new design knowledge.[31] By using morphological models in GIS programs, such as Space Syntax, it is possible to assess in advance the logic of a future system of paths, and therefore how it functions.[32]

Tangible user interfaces are focused on human-computer interaction. Such intuitive interfaces provide a rapid interaction between actions and their effects. Illuminating Clay and Sandscape are two such interfaces, with which the designer gives shape to the landscape by moulding 'three-dimensional clay or sand'. At the same time, the characteristics of the

15 Design rules, such as plot size and the amount of greenery, are translated into a spatial configuration in a computer model. This result is evaluated by designers – a process in which the rules are constantly adjusted and new alternatives generated. On the left is a computer simulation of a land parcellation study for the De Draai urban development plan in Heerhugowaard, in the province of North Holland. The drawings show the detailed town plan. (Source: Karres and Brands landscape architects in cooperation with ETH Zürich, team Kaisersrot, 2009)

16 Globus Cassus is an award-winning art project about a conceptual transformation of the planet Earth. Computer-generated three-dimensional shapes formed the basis of imaginary landscapes such as *Die Geomorphe Stadt* (The Geomorphic city). (Source: Christian Waldvogel, 2004)



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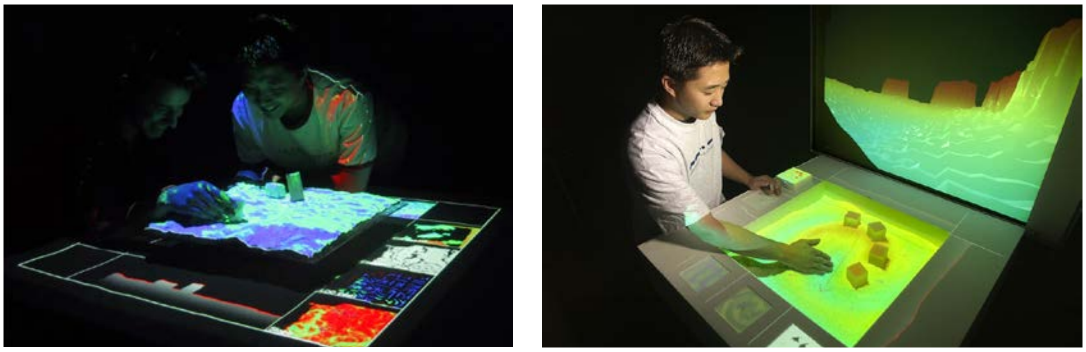

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17 Illuminating clay (left) and Sandscape are examples of 'tangible user interfaces', with which there is a rapid interaction between actions and their effects. The designer shapes the landscape by moulding 'three-dimensional clay or sand'. The landscape thus formed is calculated and displayed on screens. (Source: Carlo Ratti, MIT Media Lab, Tangible Media Group, 2002)

18 Prize-winning presentation for a new visitors' centre in the Oostvaardersplassen, a Dutch nature reserve on the north-western edge of the province of Flevoland, not far from Amsterdam. GIS, CAD, 3D modelling and image processing were combined to show the spatial qualities of the plan. (Source: Vista landscape and urban design in cooperation with Olaf Gipser architects, 2010)

19 An exhibition at the Beeckesteijn estate shows the development of the Kennemerland landscape, a coastal region in the north-western Netherlands, by means of a sequence of maps that are projected like a film onto a 3D model made using GIS-CAM. Associative pictures conjure up the feel of a particular period in time, while a voice tells the story. (Source: Steffen Nijhuis, Michiel Pouderoijen, Joris Wiers, TU Delft, 2010)

landscape formed are visualised on adjacent screens, for example contour lines, water drainage patterns and gradients (Fig. 17).[33] Digital drawings can be immediately translated into physical models and prototypes of objects by 3D printers, CNC-milling or laser cutting. The combination of CAD and computer-aided manufacturing (CAM) makes it possible to produce designed elements straight away.

Applications in presentation and communication

Presentation means effective communication and the transfer of information, knowledge or ideas to stakeholders or the general public. Digital media are used for an efficient transfer of information, knowledge and ideas. In landscape architecture CAD, 3D modelling, image processing and desktop publishing are widely used to make plans presentable with the help of computer graphics (Fig. 18), posters and reports. With the support of digital multimedia presentations, clients, the public or jury members are informed about the substantive qualities of the plans. Virtual environments and simulation laboratories can guide interested parties through a digitally constructed, three-dimensional space in the future or in the past.

CAD and building information models (BIM) are growing in importance for collaboration in groups, for example for elaborating and implementing plans. Computer-produced technical drawings, such as planting schemes and surfacing details, show how something needs to be made. With BIM, quantities and costs are calculated and ultimately translated into budgets and specifications.

Communication and interactive planning in landscape architecture are supported by digital media facilities such as group decision rooms, multi-touch tables and luminous tables, sometimes equipped with decision support systems. With such media, stakeholders sit in a room or at a table in order to be informed, or to take part in thinking about a spatial task.[34] Dynamic digital projections onto models have proved effective in conveying information and knowledge to a wider public (Fig. 19). The Internet and social media play a role in marketing landscape architecture practices. Websites show a firm's expertise, ideologies and project portfolios, and social media are used by practices to distribute information about their most recent activities.

'Location-based services', 'quick response codes', 'augmented reality markers' or 'points of interest' based on GPS provide information about objects and landscapes on smartphones and tablets. In time, image recognition will become more important here, and not only the code or the marker, but rather the entire image will be recognised as the basis for an augmented reality. Computer images or information will then be added directly to real pictures. Reality will be merged with a virtual world as part of communication about a spatial situation in the past, present or future.

Perspective

This book shows that digital presentation and communication are becoming increasingly important in daily practice, as an 'extension of the hands'. However, the possibilities offered by digital media are not yet being fully exploited. In particular those applications in which digital media are used in the creative thinking process – as an 'extension of the brain' – still offer a wide range of possibilities for development.

Digital media are developing at high speed. Every day there are new technical possibilities and specialist software is increasingly user-friendly. Digital media are becoming more intuitive and interactive, and working environments more dynamic. Work is in progress on an improved digital infrastructure in order to make up-to-date and reliable information available online and accessible to all.[35] In addition, digital media can help with the increasing demand for multidisciplinary and flexible working, in order to find solutions to complex problems together with people from other fields and with stakeholders. Here, there is a lot to learn from architecture, where we can speak of a 'real' digital culture.[36]

Educational and research institutions have an important part to play in developing the profession in the area of digital media. They must take the lead in inspiring students, building up their knowledge and passing it on, and adding new tools to the traditional craftsman's toolbox. This means that digital media and their application in research, design and presentation should be part of the curricula for teaching and research.[37] As a result, landscape architecture will develop into a digital culture in which GIS, CAD and BIM are as well-established as pen and paper.

It is not that digital media replace analogue media – they are complementary. They both belong in the toolbox available to landscape designers and researchers. Each tool, whether digital or analogue, has its own qualities: hand-drawn sketches and models are just as important as computer-generated information or virtual 3D landscapes. Site visits cannot be replaced by digital panoramic photographs, because it is important for people to use their senses out in the field in order really to experience the space. Drawing by hand will always be an important part of the thinking process in terms of coordination between the brain and the hand, and observation through sketching.[38] The use of digital media deserves a proper place alongside traditional media. It is worth investigating the possibilities offered by digital media and making efforts to become skilled in using them.

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