MEDICAL ANIMATION IN EDUCATIONAL VIRTUAL ENVIRONMENTS AND ITS EFFECT ON MEDICAL REALITY PERCEPTION

Amany Farouk Ramadan Ismail
Faculty of Fine Arts - Alexandria University
faroukamany@yahoo.com

ABSTRACT
Medical animation as a visual simulation is a very effective tool in communicating medical information with more emotional impact, and more compelling, memorable, objective and succinct at a faster rate more dramatically than traditional dry oral or written formats. Medical animation plays multiple roles in shaping the notion of medical reality. It is an integral aspect in teaching, learning, and communication. Animation modules provide patients, medical educators, healthcare professionals with visual support, increasing understanding and retention of important issues, so they can develop mental models to understand the behavior of a complex physical system in the real world.This graphical representative medium doesn't only reflect and report reality, but also filters and shapes understandings of the mechanism of action of a biological system, bio-medical technology, pharmaceutical drug or an anatomical process.This paper demonstrates medical illustrative styles and the use of animation characteristics as an instructional communicative tool for medical educators and patients to experience situations through edugraphic games in a virtual environment that may be difficult to experience in reality. This paper aims to highlight an important question: does medical animation represent reality in a fully accurate or proportional way or it has sometimes false appearance due to the user's perception, or mainly due to subjective impression as well as illustrative manipulations of artists and designers as being creators of visual simulations? So getting misrepresentations and misinterpretations question the credibility of documentation and prediction of medical subjects.Finally, ended to several results the most important are: the variations in illustrative styles in medical animation depicting the movements, process of the inner workings of biomedical issues depend on spatial and temporal design considerations, perspectives, angles of views of the illustrated elements and techniques used to create proportionally accurate motion visualization in a virtual environment. Continuous co-operation between scientists and creators as media artists, designers and animators has to take place in order to achieve scientific validation of the illustrated reconstructed models and to maintain accuracy, consequently affecting the communication and perception process.

INTRODUCTION
Visualizing complex and dynamic medical scenarios is the key in the analysis and understanding of these scenarios. Medical animation as a reality depicting visual medium plays a fundamental role in the notion of medical information and health care culture. (Patrick 2018;Hajar 2011;Stephen et al 2005;Oai& Ning 2013)For patients and low health literacy people animated videos have been found to be effective, eye-catching in providing information, as it is perceived as familiar and accessible across age groups, cultures and literacy levels, it may hold the attention of viewers and improve patient recall. For medical educators animation has shown to be more effective for conveying symbolic theories and demonstrating key concepts of devices, procedures, and technology advances by delivering clear visuals in a simple format, with sufficient fidelity to cope competently with real-life critical situations. It is also a key strategy to teach crisis resource management skills. (Sheba et al 2013;Matt 2016;Datta et al 2012) For medical experts and healthcare professionals as scientists taking management decisions, depicting their own understanding about the scientific data, animation helps to gain insight into the information they are studying engaging the imagination besides revealing all the details of the subject converting complex scientific information into a compelling visual which tickle their imagination as thinkers and thought provokers(medical-animation2018) to expand their ideas, facilitate sharing of information with other scientists and researchers.

Delivering medical reality as animated visualization is particularly significant because it involves human life, especially in a virtual environment as virtual reality, where users are fully immersed removing their reality ,or augmented reality where virtual presences is allowed to be blended into their reality with minimal interference. (Herron 2016). Medical animation can be combined within virtual environments which offer skills in contexts that users could never participate in naturally, to see features that are invisible in real environments as cellular and molecular structures and provides a training environment that is rich and responsive as surgical or clinical training to control variables that are not possible to control in the real world, and to see these in action.(Oai. & Ning 2013)

Medical animation may be viewed as a standalone visualization, such simulations may be viewed as an animated scene or time line or a process as mechanism of action animations or as emergency care instruction

animations.(Choa et al 2008;Choa et al 2009)with the possibility of using interactive controls in different levels. The simulation of hand-eye skills using haptics is another possible use of medical animation technology, as the one that stems from the replacement of cadavers in surgical classrooms with task trainers and mannequins.(Kathleen 2008) . A very important question arises : does medical animation represent reality in a fully accurate or proportional way or it has sometimes false appearance. There are many options for how the artists, as image creators, might depict medical issues with greater control over presentation, characterization, staging and timing.(Sheba et al 2013)They usually create or re-create illustrated structures depending on references as photographs, drawings, a live recording, developing videos, medical imaging[1], movies, or links to either as a medical experts' idea or an assumption. References are the basic and the most important beginning point of creation or depiction, though must be verified to provide accurate information for animators to show preference for coloration, style, movement, complexity, realism in design. That can help accurately to communicate the importance and meaning of what is being seen in a planned and prescribed manner without compromising ethical and legal rights.(Datta et al 2012)(Biomedical, Biotech, Cellular & Molecular 3d Animation Visualization 2018)

The virtual models created on a computer passes by sequenced stages controlled by artists, designers and animators from simple to highly detailed storyboards in the concept phase till constructed models and final presentation format. The designer develops the beginnings of a script of the medical scenario. He sets up what should happen and in what order, how long the medical animation should play and how should it appear. The artists control subtle properties and aesthetic choices to achieve the clear vision of the processes as the appropriate illustrative style, color, lighting scheme and motion techniques that are suitable for clarity. Identifying the target audience and their cognitive and perceptual aspects is critical to proper animation design. (biomedical-3d-animations2018)(Medical animation 2018) Animation programs offer increasingly adaptable and realistic tools, which give wide free space to the artists to construct, change and correct already rendered animations to users specifications. So this paper pegs two main questions: does the artistic intervention in creating medical animation in educational environment shape the notion of medical reality ? does the constructed medical illustrations, degree of manipulation and credibility of motion construction, editing techniques consequently affect the user perception and experience.?

EFFECTIVENESS OF EDUCATIONAL VIRTUAL ENVIRONMENTS ON MEDICAL REALITY PERCEPTION

The mechanisms underlying the educational benefits of animation in serious[2]/edu-graphic[3] games in virtual environments as an instructional tool lie in their capacity to improve the enjoyment, engagement, and motivation of users. Educational games teach complex cognitive skills, provide meaningful and challenging tasks, with flexibility in use and scalability where users can directly experience the consequences of their decisions in an extraordinary new way, from unique points of view and motivate them to go deeper where they are immersed in complex, feedback rich problem spaces. They can practice specific scenarios which help them effectively transfer the acquired skills to the real world. The effect of educational games on medical users satisfaction, knowledge, skills, attitude, and behavior are still in debate, depending on the validation and reliability of information, mode and the delivery format of medical content and other aspects. (Dankbaar et al 2017;S. De Ribaupierre, et al 2014 ; IV. Alexandrova et al 2011;Christopoulos 2013)

The game scenario designer often has his own personal view on how to arrange the scenario. The designer can control different presentations of animation in educational games as:

- one scenario which usually do not confer actual practical skills because it prevents the user from being fully immersed in the situation such simulations may be viewed passively (Figure 1)[4]but sometimes interactive controls are added from low to higher levels.(Figure 2)[5](Kathleen2008) The scenario

[1]Computer imaging in medicine :using medical scans, such as computed tomography (CT)using thin pencils x-rays beams or magnetic resonance imaging (MRI)using large magnetic fields with pulsed radio waves. Ackerman, MJ. (2011)

[2]A serious game is a game designed for a primary purpose other than pure entertainment. serious games are a subgenre of serious storytelling, where storytelling is applied outside the context of entertainment, where the narration progresses as a sequence of patterns impressive in quality.(lugmayr, artur et al 2016)(djaouti, damien;et al 2015)

[3]educational graphics, or edugraphics, are graphic visual representations of educational information intended to simplify social culture content, the term "edugraphic" is born from a related term :infographic the first international conference on graphics education, was held in alvor, algarve, portugal 1993 with the name edugraphics. santo, harold p. (1993).

[4]Figure 1: watch video on https://www.hybridmedicalanimation.com/work/virtualreality/tradeshow-vr-intracellular-experience/(accessed February2018)

[5] Figure 2: watch video on https://3d4medical.com/support/complete-anatomy/multiselect and for more information watch also the cystic fibrosis-crispr hololens experience trailer https://www.youtube.com/watch?v=XWCd5k2ygrI(accessed February2018)

usually designed to explain surgical procedures or pharmaceutical mechanisms of action in terms simple enough for a layperson to understand, also may be used in order to get fully informed consent from patients facing surgery or medical treatment.(Lai-Chu et al 2011) or learning mechanism of action of certain subject.(Figure 3)[6]

– multiple scenarios :where the level of interactive training and immersion can be increased by creating a realistic working environment as virtual reality based training exercises to teach procedural skills in situations of varying complexities as surgical simulation, a simulated intensive care unit coupled with feedback from observers(Figure 4)[7]or High fidelity Software Simulation which is designed to allow the mimicking of human physiological conditions for a variety of clinical scenarios,in addition to high fidelity manikin where realistic, programmable manikins behave like real patients that are capable of simulating a wide range of clinical scenarios; including simulating cardiac arrest, seizure, etc. Finally,Virtual Patient Game where interactive clinical scenarios take place in an entirely virtual world designed to practice team training in high risk situations like avatars within a virtual health facility. (Kononowicz et al 2015). Role-playing with someone taking on the role of a patient, interacting with the trainee, was one of the first types of serious games introduced in nursing education(Minhuaet al 2014)

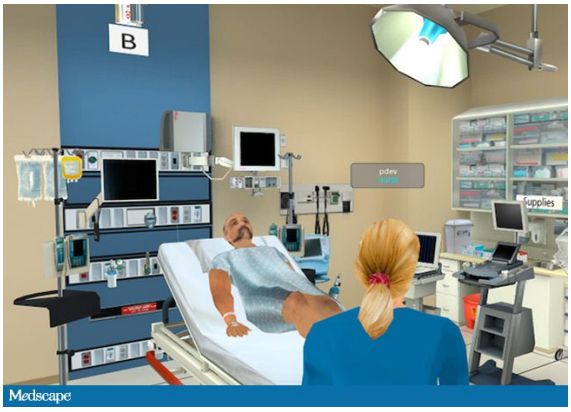

Figure 5 : A Digital Revolution: Games, Simulations,
and Virtual Worlds in Nursing Education
(Stokowski2013) https://www.medscape.com/viewarticle/780819_4
(accessed February2018)

More accurate structure in the design process must be taken in consideration, thereby creating more effective scenarios, guiding design principles are needed to help game scenario designers where the focus lies on one scenario or on the progression of multiple scenarios.(Hartog 2009)

Coming to the concept of 'unconstrained play' rises risk-free training , and brings into sharp focus the necessity of a clearly articulated well-designed accurate instructional content for medical educational games. Selecting the games, the sequence order for the user, the interaction mode are main considerations, the games are adapted to the current level of the user to ensure the optimal degree of challenge without cognitive overload. The majority of users prefer to explore with a human guide, because it allows direct interpersonal interaction with which the educator can immediately adapt to the users and solve doubts or provide more information. The role of the medical expert as a teacher and a guide should ensure that the user does not over-learn one small fragment of a necessarily broad skillset. (S.DeRibaupierre et al2014;Hargreaves2018;Hartog2009; Christopoulos 2013)

The plausibility illusion which is the illusion that what is apparently happening in the virtual environment is really happening and defines that the key component for its realization is the existence of events in the virtual world over which the user has no direct control . So a bidirectional flow of information and action, by handing at certain moments control over to the game, so that not all information and actions would come from the educator. Through the usage of in-game characters at the various interest points in the virtual environment and mainly during the completion of a task, medical information is provided and events initiated which advance the

[6]Figure 3:watch video on https://www.hybridmedicalanimation.com/work/animation/vr-real-time-capabilities/(accessed February2018)
[7]Figure 4:watch video on https://www.hybridmedicalanimation.com/work/virtualreality/medical-device-virtual-reality/(accessed February2018)

storyline. Both the educator and user are forced to cooperate in order to advance the story. The reception of information and tasks both from the educator and the animation allows not only the direct participation in an interactive experience but also the passive observation placing the user in the middle of the action. (Christopoulos 2013). If the game is so engaging, the context and conditions in a scenario have to be designed taking into consideration: task (subject)arrangement, complexity progression and the balance between short and long cyclic scenarios.

Designing a game scenario mainly consists of the translation of learning goals into specific elements in a scenario to create the right elements associated with each competency or learning goal by confronting the users with various elements of the scenario - in clinical or emergency situation -they are required to assess the situation(situational assessment), make a decision and task selection and sequencing, followed by the task activities, thereby acquiring the necessary competencies (Hartog2009) in such a way that the learning goals are reached, and the user as a learner has experienced all aspects of his real job and has built the necessary practical experience. Experts as well as educators will have to work in collaboration with the artists , designers , animators , computer software or game developers. Ideas can be tested very early in the concept process or in the design stage, or through creating a clickable or coded prototype. It also means that a scenario should give proper feedback on the performance of users. The elements in the final scenario should consequently be 1) of educational value, 2) technically feasible and 3) realistic. in which a conceptual design is continuously refined into an implemented final version. Objective measures based on speed and accuracy at all levels not only provide an evaluation of the learning process, but serve as the scores for these gaming activities in virtual environment for healthcare education. (S.DeRibaupierre et al2014;Hargreaves2018;Hartog2009)

When evaluating medical animation in an educational game a fundamental question arises:How well does the final visualization represent the underlying medical information to acheive the user's goal ?This question involves two aspects:

First:the evaluation of the technical efficacy, intrinsic quality, or technical image quality of the representation. How well does the visualization approximate the medical information to be understood? Is the visualization realized through graphic illustrative styles and motion editing that will produce the final animated images?.Though analyzing the characteristics of the model, as timings, rendering, processing, framerates within its hypothetical/original context, as well as matching any hypotheses alternative to the shaping of some of its parts are basic considerations of design. In addition to checking if the visualization:1)successfully highlights the target medical information, does it distort this information, if it transforms it in some way,while providing context for that information.2) transforms nominal interval, and quantitative information properly.3) reveals trends, patterns, gaps, or outliers.4) provides insight to some situation or answer a specific question.(Aragon 2017 ; Hartog2009 ; Beatriz &Dillenseger2005 ; Beatriz 2008).

Second the evaluation of the semantic efficacy: the performance of the user at interpretation tasks when using the visualization, which implies the understanding of the underlying medical information, considering the purpose of the medical visualization and who is the intended audience, the user's motivation or goal: how well does the construction of a specific model from the data help the users to understand the underlying subject and perform their task? examining readability of the visualization whether it is immediately understandable after a short period or does it require excessive cognitive effort? How does this make users feel? Is the process clear? Are designers thinking of the user's wants and needs, or their own vision only? What do the designer want users to do?

Strategy is then translated into design through illustrative and technical styles determining the emotional reaction to the visualization,whether it is generally positive or negative, with examining in detail which helps to better understand not only what works and what doesn't, and also by how much, to gain insight into why.(Interrante 2005;Aragon 2017;S. de Ribaupierre, et al; Katharine 2018;Beatriz &Dillenseger2005;Farouk 2017)

MEDICAL ILLUSTRATION CREDIBILITY AND DEGREE OF MANIPULATION:BALANCING CREATIVITY,CLARITY AND REALITY

Artists have been visualizing medical world bringing a reinterpretation of medical issues throughout centuries in various forms of artistic expression. Artistic intervention of medical illustrators and animators as image creators presents a potential tool for facilitating and deepening communication that redress the balance of power in interaction between health professionals, medical experts, medical educators and students or patients. The artist goal often concerns the provision of emotional insight, rather than purely medical education knowledge. The

artist doesn't act as a conduit for science, but account for a medical aesthetic beyond didactic when interpreting and visualizing medical data.(Tsafrir& Ohry 2001; Hajar2011).

An artist can articulate an alternative aesthetic illustrated image to that of reductive plain medical information. He has the ability to tell stories through medical animation and potentially widen accessibility to medical imagery. This does raise several questions about the integrity of the illustrated and animated images :How far does the artist interpret the medical data? Does the artist reflect or construct reality? exactly or distortedly? Does the artist imitate and project or embody and build up medical reality?.A major issue is the aesthetic choice of where to strike the balance between realism and clarity in medical animation. (Weber2002; John2010; medical-animation-2018)

Illustrating a medical concept is difficult and can be tricky.(Hajar2011)Artistic manipulation is regarded as involving material changes in the processing of an image construction through the addition or subtraction or modulation of content.(Boering 2015) Medical images' manipulation has been used legitimately, to allow superposition or clarity enhancement, for medical educational or experimental and scientific purposes without physical intervention, to avoid misrepresentations and though misinterpretations.(Tsafrir& Ohry 2001)But artists as visual communicators adapt certain techniques, not with an intend to change the truth of what they were attempting to articulate, but to make images featured and characterized **(**McNally2015)to attract the attention of the recipient and keep him on the path of the image not through the process of revoking the reality but may sometimes beyond the limits.(Mike M.1993)Such manipulation questions the credibility of documentation in medical animation.(Tsafrir& Ohry2001) Some artists think any degree of manipulation is possible so they may filter and manipulate for the sake of aesthetics striving for an impossible level of perfection and idealism in their work. **(**Lyttle2015)

Artists aim to highlight medical world and tell stories in their own artistic vision depending upon their own experiences plus the credit medical reference which determine the motivation behind each stage of the animation from the concept creation to the final representation.(McNally2015)for example medical illustrators draw the steps taken during procedures and create illustrations of both healthy and diseased body parts to explain the effects of medical conditions. (Hajar 2011) demonstrating how healthy tissue functions or how various ailments impair that function. Claiming that neither illustration, nor animation certainly isn't all the truth, an artist can formulate or stylize the same animated elements in different ways, with different interpretation of the real world.**(**McNally2015)Manipulation is not equivalent to processing or editing through an illustrative style. All images are processed or edited, and levels of processing are aesthetic judgments and do not by themselves violate real medical reality information. The only point at which processing becomes manipulation is when transforming significant parts of an image(Campbell 2015) as addition or subtraction to the medical content or moving around information blatantly.**(**McNally2015)The medical artist should draw or animate the medical issue with scientific precision and at the same time brings artistic creativity to his work. (Hajar2011)

Creating medical animation requires a significant amount of technical experimentation prior to any creative intervention. Visualizing real reality may require the highest degree of mechanical artificiality. Articulating, stylizing, processing, editing and even manipulation has penetrated so deeply into the reality construction in order to appear real .'The clearer real reality is suggested the more constructively there is behind it'. The appropriateness of a more abstracted visual narrative need images that describe medical scenarios in a more accessible and holistic way, as rendering on a higher level of abstraction, semantics and user interaction have to be taken into account.(John,M2010 ; J. Diepstraten et al 2003 ; Weber2002)

There is a potential for artistic intervention at almost every stage in medical animation practice, from the concept (creative) development including; Storyboarding, (Figure 6) animatics or pre-visualization (Figure 7)[8], concept art (character and environment)passing by the production phase as character creation, the environments that run the story of the animation, modeling, texturing, rigging, animating, lighting, rendering and animation tests,(Figure 8) ending to post production phase including editing compositing, adding visual and sound effects,titles and credits andfinal rendering and presentation. (Boering2015 ; Getting start with a 3D animated movie 2015)

[8] Figure 7 : watch animatics on http://www.chicagomedicalgraphics.com/animation/

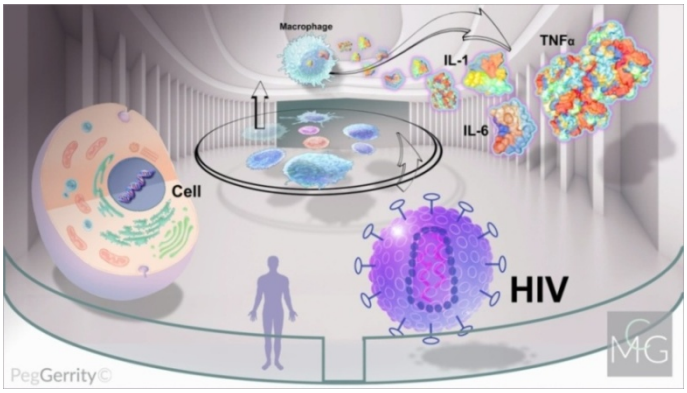

Figure 6 : biomedical virtual reality Storyboard
(artistic intervention in the concept development phase)
http://www.chicagomedicalgraphics.com/animation
Chicago Medical Graphics 2017/accessed February 201

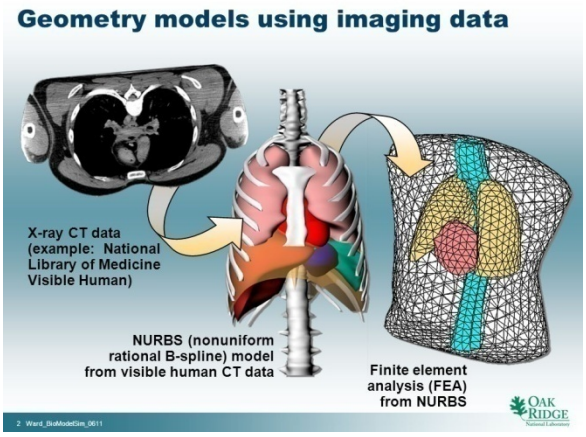

Figure 8: (artistic intervention in the production phase
(from medical imaging to artistic editing)
Presentation on theme: "Biomedical Modeling and Simulation
Richard C. Ward 2007http://slideplayer.com/slide/4806689/(accessed February 2018)

There is and always will be much debate about the degree of modifying of medical illustration. **(**Campbell2015)The mere fact of replacing or changing places to produce an image involves a choice that might represent reality in a partial manner.**(**Boering2015). This doesn't mean to emphasize and suggest a culturally critical pessimism in the sense of a loss of the reality or a distancing from one reality and proposing a reality of distorted media constructions.(Weber2002) and also doesn't mean to direct the composite images to falsify awareness and hide the truth, and perhaps to raise the value of surface issues, temporary and transient things over the real, because the images are no longer based on similar , but on the basis of composition and hybridization, which gave a way for the potential of counterfeiting and forgery.(Mike 1993)So minor changes may be accepted while excessive changes are prohibited, but what counts as minor versus excessive changes are necessarily interpretive with artists and judged by medical experts who value those images on a case-by-case basis. There should be a clear line demarcating these concepts, the ways used to explain the rules on artistic manipulation should be cleared improved for example setting up a series of video tutorials that show artists what kinds of manipulations are not allowed, regardless of the technical process through which that addition or removal is achieved.(Boering2015)An artist and scientist interaction is extremely useful in advancing art and medical issues.(Hajar 2011)

FORM STRUCTURE OF ILLUSTRATIVE STYLES IN MEDICAL ANIMATION

Constructed images in medical animation has a high ability to attract attention, as it guides the user as students patients or medical educators to meanings that help his mind to recognize and translate its content and relate it to familiar reality. The constructed illustrative styles may raise mystery and surprising in the image especially when finding a difference or unpredictable when linking between the real world view and the user physiological

and social needs. The artist is able to influence the recipient using unusual forms, and combination of existing and non-existing visible. A huge potential ways and methods of various images' manipulations depict, reflect, produce a new or unusual represented vision as 1) modification of familiar forms 2)changing or modifying known laws of nature 3)interactions or blending between different forms (metaphor) 4)giving unreal features or characteristics to certain characters 5)Combining things that are impossible to meet in real world. Those techniques consequently affect the recipient mental and visual perception and shape the notion of medical issues. When he sees such strange and different forms from what he has accustomed to and stored in his mind, he attempt to find a relation between these forms and others, the mind begins the process of building a new database of these forms, which may require a relatively long time to realize the differences with new characteristics, then he tries to link between them finding convincing reasons for these changes, until they are well understood and interpreted. The process of cognition is equipped and prepared to recognize each element on its original real form, as well as to recognize its properties and characteristics that are familiar to the mind and have acquired knowledge during experience and perception.(Mikkel & Rudolph 1992 ; Mike 1993 ; Giemsa 2007;Wettlaufer 2003). so adding any new modulated information is at stake, especially that medical information is almost new for the user.

Creating medical animation depend mainly on identifying the appropriate kind of illustrative style which represent the medical issue and affects its validity and reliability. Those styles are specified to encode particular information about important features of the subject within the graphical representation. Concentration on certain issues and subjects with certain representative styles leads the users to perceive those issues as more important than others (John 2010 ; J. Diepstraten et al 2003 ; Weber2002).

Concerning the degree of visual realism whether it is actual/apparent realism or iconicity/ symbolic, there are different illustrative styles how the medical subject can be represented graphically: If the purpose of the medical issue is to depict a specific location of an organ for example and the users are supposed to recognize elements in that issue, then the degree of realism should be high, and it will be necessary to use the most detailed information which is easy to interpret with extraction of the relevant features, as accuracy addresses the issue of the truthfulness or fidelity of the visualization imagery to the actual or expected appearance of the medical subject. Medical illustrations can be created as perspective representations, the more natural the perspective the more complex it will be. Using vanishing point perspective depict bodies as realistically as possible, while parallel perspective may be used to improve the recognition of the shape and structure of objects, their orientation, or spatial relationships in non photo realistic styles.

Realistic representations depict the medical subject and its physical characteristics in the simulated environment depending on creating and composing alternative world to reflect facts as close to reality as possible and suit the medical subject documentation.The task is to record imagery in all its details and simulate the desired effect for convincing using computer graphics imagery as pictorial elements to create the illusion of reality which in fact might either does not exist or cannot be seen by the human eye. (Figure 9)[9]Highly stylized realistic illustrations with most details available in the medical information requires a great deal of knowledge about both the 3D modeling and the rendering of a specific type of virtual environment, as hyper real visualization incorporates and often capitalizes upon photographic limitations such as depth of field, perspective and range of focus to create a tangible solidity and physical presence through subtle lighting and shading effects so the users can recognize the features' identities in the virtual environment which affect spatial cognition.(Figure 10)

[9] Figure 9: watch video on http://www.peggerrity.com/animation/

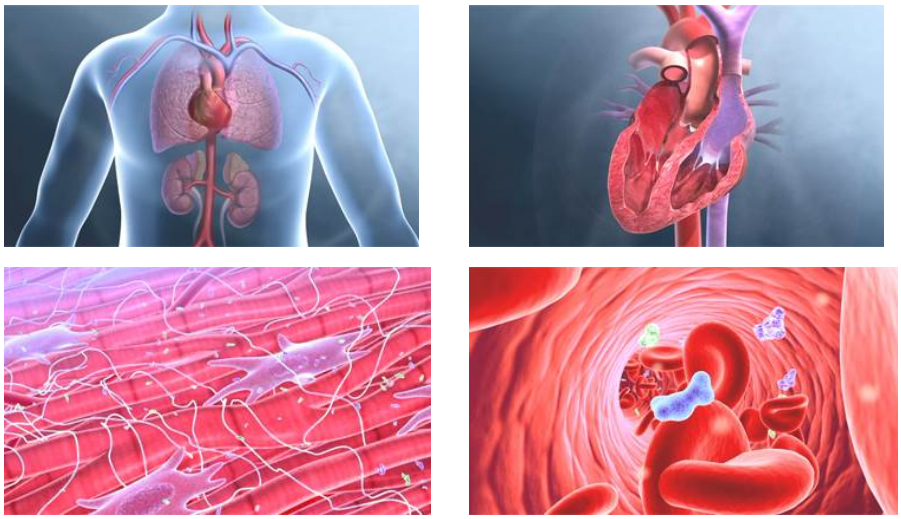

Figure 10:Realistic representation with various point of views depict the medical subject and its physical characteristics in the simulated environment
still scenes:Diastolic cardiac insufficiency
watch video on http://kostudios.com/diastolic-cardiac-insufficiency
KO Studios © 2013 All rights reserved

Non realistic representations as stylized and abstract imagery can reduce visual complexity of images, and the level of detail which guide the user's eye towards important features in an animation. Non realistic representations may take several forms as iconic,sympolic, and others to visualize abstract information, communicate spatial complex and thematic information for medical issues. (Figure 11) These representations facilitate guidance of a user's gaze to prioritized information and predicted steps which may exist only in the scientist's imagination. When it comes to concentrate on essential features and reveal concepts, low visual realism is applied which requires interpretation of the abstract symbolism in the animation. It may possible to reuse existing objects or drawn elements but adapt the size and orientation of each element as it will change wherever it appears in the new issue. (J. Diepstraten et al 2003;Giemsa, 2007;Dykes et al 2005; Bishop & Ecrat 2005; Kettunen et al 2012; Farouk 2016)

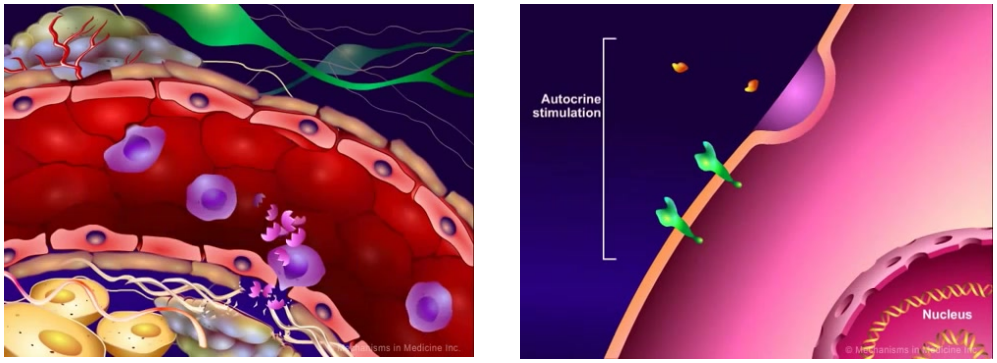

Figure 11: non realistic representations ofstylized imagery
reduce visual complexity of images, and the level of detail
still scenes: mechanism of action- intro to cancer biology
watch video on https://www.pinterest.com.au/pin/843439836434445151

medical scenarios may vary between realistic and nonrealistic or a combination of both styles based on the relation between the representation and its referent and the complexity of the information represented.The illustrator has artistic freedom to use various stylistic devices to support the purpose of the animation.The use of prespectives, graphic devices and simplifications are valuable tools for emphasising key details in an animation.Illustrations reveal the shape and appearance of important parts,plus the position and orientation of these parts in the context of the surrounding structures. However, creating illustrations that clearly depict the spatial relationships between parts is not an easy task. The primary problem is matching and managing. Most complex 3D objects contain many tightly connected and intertwined parts that occlude one another.

Illustrators carefully choose viewpoints that help the users to see the spatial relationships between the internal target parts they are interested in. Typically, the viewpoint not only centers the target parts in the animation , but also minimizes the number of occluding structures. This strategy makes it possible to expose the parts of interest with relatively few cuts, leaving more of the surrounding structures intact for context.For example, when depicting the inner workings of biologic systems as the events that take place inside of cells which are nearly invisible to all forms of visual analysis. If interior parts are to be shown, the occluding parts can be shown as transparent, or completely cut away, or removed in sequence as during a surgical technique where inner structures gradually come into view as the surgery progresses. (medical-animation2018)There are variety expressive visualized representation methods that artists can create with several illustrative styles, the purpose of the animation distinguish the choice of that representation method, the most important of these representations are: 1)Cut-away/cross section views where a section or part section which allows to see through the surface and perceive other surfaces or structures behind.(Figure 12).(J.diepstraten et al 2003;Giemsa2007;Ivan&Gröller 2005;Farouk 2011)

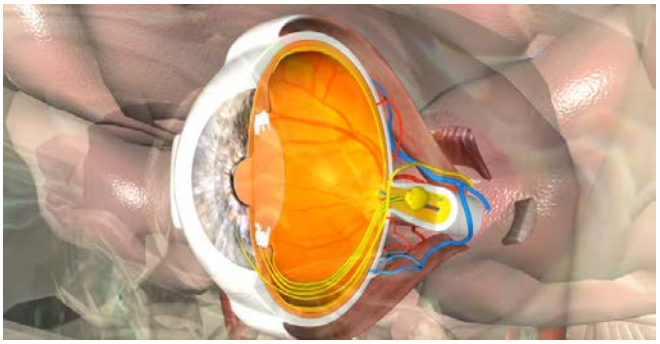

Figure 12: Eye Anatomy Cross Section
still scene : 3D Medical Animationwatch video on https://medical3danimationcompany.com/project-attributes/medical-illustration/page/2/(accessed February 2018)

2)Ghosting views in which transparency is used as the dominant method. so elememts or objects are semi-transparent illustrative views.The inner parts of an object can be seen by displaying the outer case as if it is transparent.(Figure 13) (Giemsa, 2007;Ivan& Gröller 2005;Farouk 2011)

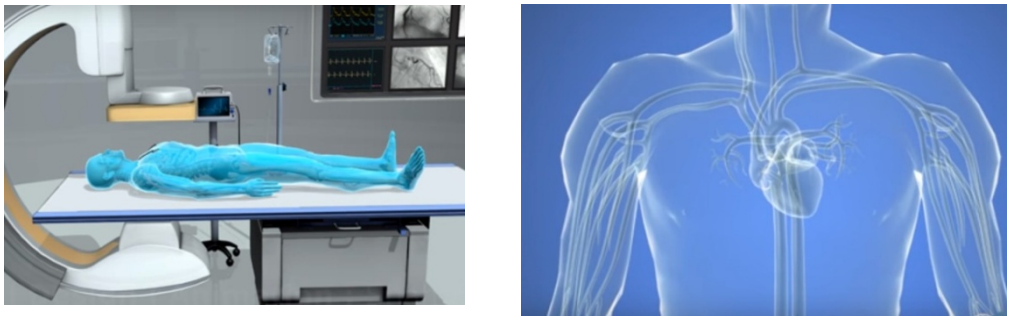

Figure 13: ghost view Cardiac catheterization - 3D Animation 1080p
still scenes watch video on https://www.youtube.com/watch?v=Y2fmJgt3cms/
(accessed February 2018)

3) Exploded Views in which the spatial arrangement of features are modified to uncover the most prominent ones. It is also a very effective way to present assembly instructions.(Figure 14)

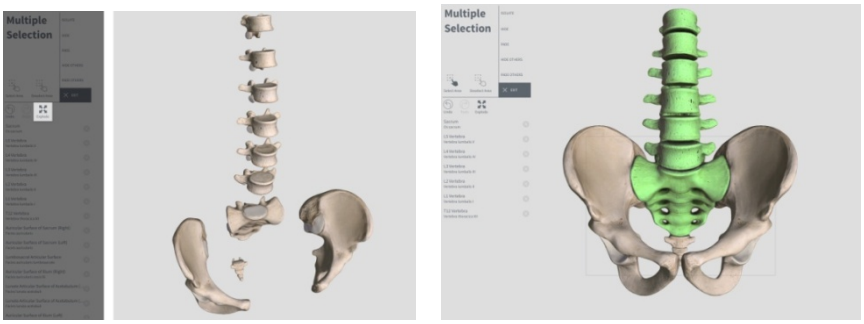

Figure 14 : exploded views .Control Multi-select with Surface Dial***still scences***
watch video on https://3d4medical.com/support/complete-anatomy/multiselect
(accessed February 2018)

The artist controls constructing stylistic devices to shape the user notion of medical reality are varied which enables him to percept the meaning of the illustration more easily such as line weights, line types which may form patterns to convey regular and irregular textures through choosing appropriate weighs and spacing for those lines. Illustrative rendering techniques include the use of non-physical or exaggerated lighting and shading models that emphasize the shape, texture and reflection properties of the depicted elements. The artist should think about what to depict and how to arrange the parts so that the structure is clear and avoid making the visualization too ornate as too much detail will distract the viewer and obscure the meaning. In this context the effects and strengths of various stylistic devices become apparent as it enables the user to see the meaning of the illustration more easily.(Mitra et al2010;Giemsa 2007;Ivan& E.Gröller 2005;Farouk 2011)

MOTION CONSTRUCTION AND MOTION EDITING IN MEDICAL ANIMATION:
The main goal of medical animation is to synthesize the desired motion effect precisely which is a mixing of natural phenomena, perception and imagination. The animator designs and specifies the dynamic behavior of the elements in medical scenarios not only with his mental representation of causality and academic backgrounds but with a help of a medical expert to produce an accurate dynamic visualization in a fraction of the time. He tries to transform the vision of the elements' behaviors into a realistic and conceived animation depending on the required result and how the user is going to interact with.(Thalmann2001;Steven et al 2003; medical-animation 2018)

The motion in medical animation can be created or derived from a reconstruction of the subject with motion control methods as keyframe (computer animation), simulations and motion capture to translate the desired motion according to the context subject. Amotion control method specifies how the mechanism of action of elements in a biological system, bio-medical technology, pharmaceutical drug or an anatomical is animated. A combination of blending of methods can be used and provide good results. There are two aspects of a motion representation: the representation of the medical element character at any given instant in time and how these specific instants are varied across time.(M. Jung et al 2000;Thalmann,2001;Patrick 2018)

The user as a recipient is not assigned to analyze the motion techniques used in medical edugraphics , whatever the method is, his relationship to those techniques is a relationship of vulnerability, not analysis, and the process of understanding and perceiving the contents of the medical subject comes in the first place. If the user begins to analyze the construction of used motion technology, it will get on the content or the meaning presented, which separates the user from that meaning in favor of technological use . Using motion techniques within the context has a direct emotional impact on the user so technology must remain within the context of the receiving sense and not perception . Diversity and differences in techniques, just are creative agents that the creator seeks for high communicative level, to achieve more interaction with the user. This means to send signals and semantics which help to build the imagined image in his mind . responsiveness with intents and desires arises as a result of mental and emotional connection between the user and the animation in the virtual environment . All this leads to the creation of a specific communication, whatever the motion technique used, it is employed to serve the aim of the animation and correspond to the nature of the users.

Key framing motion(key frame animation)
Creating realistic motions with accurately mimic subtle characteristics requires a great deal of skills to build objects and scenes to achieve medical reality. An animator creates a simplified representation of an object anatomy which is called skeletal animation.The position of each segment pose of the skeletal model is defined by animation variables(avars). Animators specify a series of many individual poses to create properties of the

motion using key frames to define the position and orientation of objects at specific points in time so changing the values of avars over time and the computer provides the motion in between to achieve the smooth motion of the objects.Realism in computer animation can mean making each frame look photorealistic, in the sense that the scene is rendered to resemble reality and make the animation believable and lifelike. Diagrammatic or schematic illustrative stylesc an represent physiological processes and the mechanisms of dysfunction that cause disease as an abstract concept.The animator has his own space to think and create real or false appearance of the medical elements in certain time with certain movement; what motion is going to be added or emitted depending on his accurate interpretation and understandings of the represented medical subject. (Gleicher 1999;Patrick 2018;Steven et al 2003;Masson1999;Parent 2012;medical-animation2018)

Computer simulation (simulated motion):
Simulation generates motion of objects using numerical simulation (algorithmic) methods depending on computer programs, which rely on the laws of physics and engineering to analyze the event and produce the motion.(Figure 15a-b) Simulation is the artificial representation of a complex real-world process to simulate physical processes and phenomena with sufficient fidelity and relies on the input data to be consistent with the elements in portrayed medical scenarios with the aim to facilitate learning through immersion, reflection, feedback, and practice minus the risks inherent in a similar real-life experience of which can be complicated, hazardous, expensive, and time consuming in many situations.(Figure16)[10] Medical simulation offers numerous potential strategies for comprehensive and practical training, and safer patient, the output data from simulation are fed directly into animation as if both steps take place simultaneously.One key problem facing algorithmic methods is how to describe a complicated motion or a subtle nuance. So the animator credibility creation depends upon his skills and equivalentof the constructed motion to reality. Simulation Perceptual accuracy require stability, ease of use, speed, robustness to transform science into a technically-accurate, visually-dramatic experience.(Datta et al 2012;Oai & Ning 2013; Patrick M.2018;Gleicher 1999;hybridmedicalanimation 2018)

Figure 15 a: Virtual Medical Simulation Laboratory
https://contest.techbriefs.com/2016/entries/medical/6915(accessed February2018)
Figure 15 b: Virtual Medical Simulation
https://techli.com/2012/04/government-unreal-engine/(accessed February2018)

[10] Fgure16 : watch video on invivo Surgical Simulation Trailer https://vimeo.com/193605703(accessed on February 2018)

Motion capture animation:
Capturing the motion is an aspect of creating medical animation from observations of real motion. An artist create animation from observation through several steps :1) Planning the motion capture shoot and subsequent production.2)Capturing the motion.3)Cleaning the data.4)Editing the motions.5)Mapping the motions to the animated elements.When computer animation is driven by motion capture, a real motion is recorded to a computer using video cameras and markers,or a real performer acts out the scene as if he is the character to be animated and that motion is then applied to the animated subjects or character especially in clinical or surgical animation virtual cases.Motion capture is appropriate in situations where believable, realistic behavior and action is required, as it provides a large collection of realistic motion data**.**(Masson1999) (Figure 17a-b) (Figure 18) [11] (Figure 19)[12]

Changing and editing motions seems to be a big part of the use of motion capture where reality is reconstructed. There is a need to create the observations that are then interpreted, motion capture creates a representation that distills the motion from the appearance; that it encodes the motion in a suitable form for the kinds of processing or analysis needed to be performed depending on the final result. Motion capture for animation implies that the animator will somehow be changing something about what have been recorded.in other words to what extend and how farmotion database reusability and flexibilityis going to take place.The limitations of editing come from the library of motions available to adapt, and the quality of the tools available for adapting motions to new needs.(Gleicher 1999)

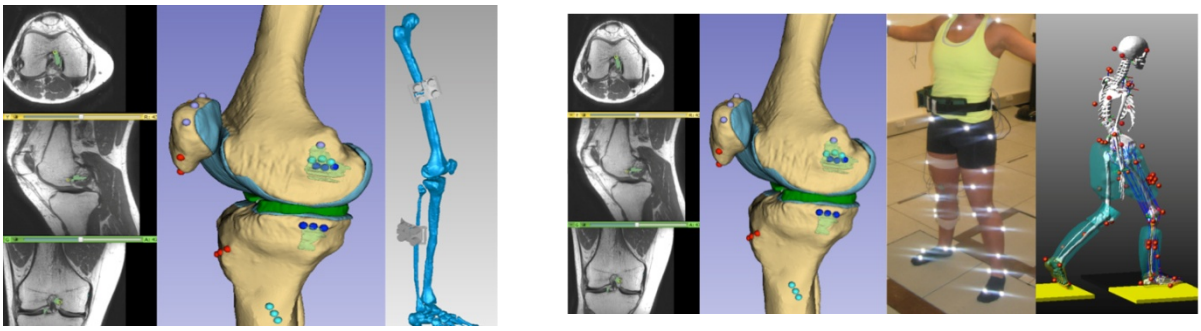

Figure 17 a-b: motion capture
subject specific con current simulation of movement and natural knee contacts mechanics
evaluation of knee ligament mechanics
still sences watch video on http://faculty.missouri.edu/guesstr/Knee%20KEM%20Video.html

MOTION EDITING
The need to control the motions of objects is an essential part of any animation. The animator as a creator control over the motion to better convey- not to manipulate - clear biomedical content which accordingly affect the user perception. Motion editing can be applied to motion created with key-framing and simulation, as well motion capture. Animators edit created, recorded or real observed motions of medical data, they often make alterations to the motion, for reasons including:

1) reflecting an accurate reconstruction through the clean-up process which is a specific type of edit to motion capture. 2) re-using the medical data for something slightly different as a different action from the exactly recorded data. 3) creating infeasible motions and impossible actions or experimenting some speculations or predicting alternatives.4)adjusting imperfections of reality.5)addition of secondary motion.
(Gleicher1999;Komura2006; Rick 2006;M. Jung et al 2000)

Adaptation, retargeting, editing and reusing motion is challenging, because the motion was acquired for a specific character within a specific environment in a specific style and mood. so constraint-based approaches

[11]Figure18: watch video on ArthroPlannerSurgical planning solutions 2014:2016
https://www.medscape.com/viewarticle/780819_4 (accessed February2018)
[12] Figure19: watch video on MyHipDynamic planning for THA 2014:2016
http://www.artanim.ch/en/projects-detail.php?id=1(accessed February2018)

specify features to be retained, new features to be accomplished with a new motion to satisfy given constraints, while preserving the characteristics of the original motion as much as possible. Relation with environments, dynamic constraints, subtle details accomplish new features for the target motion and new characters/environment,new style/mood are defined. Animators select motion segments from the database that will be modified, blended, and stitched using variety of motion editing tools.(hybridmedicalanimation 2018)

Creating a believable realistic performance and designing effective real motion through motion editing, shouldn't depend mainly on the artist imagination and technical skills but presenting the medical elements or objects' behaviors is the main goal, not how good the animator is at making something move. The animator should understand exactly the mechanics of the action of the animated elements, study how the character whether a human or an object moves: timings, arcs, speed changes ,overlapping actions compression and extension, balance, weight,motivation, the medical issue or objective behind the action, to determine the past and the following steps. Discussing the action with the medical expert or the specialist involved with the issue is very significant to determine the accurate location of the action need to happen, in a certain distance and exact timing interacting with other objects to make the action feel more responsive. Adjusting a good motion can lose something of the depicted reality, the motion may no longer be physically correct, or may lose some nuance given by the animator. Good transformations preserve important aspects of the motion by altering less important ones. The animator must look at motion editing as a creative process where decisions are made as to how best to keep the originality of the motion while meeting new needs. Over all, medical animation should have no limits on creativity, and overtly constructed imagery has much to say about medical world. But for educational ,documents and evidence images clear standards are necessary to underwrite their credibility.**(**Campbell 2015) and shouldn’t depend mainly on pure artistic imagination but should also rely on scientific facts and hypothesis of a team of researchers and experts.

CONCLUSION

Medical reality could be recorded, reconstructed or processed in as an animation in a virtual environment depending on the accuracy of the artist's references as a visual creator, and his perception,interpretation of scientific information, imagery,in addition to his constructed illustrative styles, his motion controls of medical elements in the final visualization.

Balancing realism,aesthetic and clarity in medical animation depend on spatial and temporal design considerations depicting the movements, process of the inner workings of biomedical issues perspectives, angles of views of the illustrated elements and techniques used to create proportionally accurate motion visualization.

Medical simulations in virtual environments mannequin based, screen based and virtual reality simulator provides multiple benefits to different users as medical educators and patients to understand the known and explore the unknown, practice rare and critical situations. But educational serious games for medical and health care learning is not effective and do outcome negative learning, change awareness and twist the notion of medical reality without a good evaluation of the visual content, objectives, in addition to studying the user behavior during the development of the game scenario design to create safe and controled virtual environments which eliminate risk to patients, enhance visualization, and contexts for learning and assessment.

Credibility of medical animation has to undergo several verifications to ensure the accuracy of the delivered information though bridging the gap between scientific instrumentation and the artist’s experimentation. Finally,continuous co-operation between scientists and artists has to take place in order to achieve scientific validation of the illustrated reconstructed models and to maintain accuracy ,consequently affecting perception of medical reality.

REFERENCES

Ackerman, MJ. (2011). "Visible Human Project: Getting the Data." U.S. National Library of Medicine. July 27, 2011. https://en.wikipedia.org/wiki/Medical_animation(accessed January 2018)

Aragon, C. (2016). “Evaluating Visualizations” the course by University of Washington "Communicating Data Science Results" https://www.coursera.org/learn/data-results/lecture/IBuU3/14-evaluating-visualizations (accessed February 2017)

Beatriz S. & Dillenseger,J. (2005). Visualization, Image-Guided Procedures, and Display Medical Imaging Proceedings" Volume 5744,San Diego, California, United States.doi: 10.1117/12.594549

Beatriz S. (2008). “Evaluating Visualization techniques and tools: what are the main issues?” Portugal :DETI/IEETA- Universidade de Aveiro 3810-193.

Biomedical, Biotech, Cellular & Molecular 3d Animation Visualization Services (2018) https://medical3danimationcompany.com/biomedical-3d-animations/ © 2018 Medical 3D Animation Company Dallas Scientific & Device 3D Animation for Healthcare Marketing. - All Rights Reserved

Bishop, D.&Eckart, Lange.(2005)."Visualization in Landscape and Environmental Planning: Technology and Applications". London . England. Taylor and Francis.

Boering, L.(2015)."Debating the Rules and Ethics of Digital Photojournalism"The New York Times Feb. 17, 2015. https://lens.blogs.nytimes.com/2015/02/17/world-press-photo-manipulation-ethics-of-digital-photojournalism/ (accessed 14 January 2018).

Campbell, D. (2015)."Debating the Rules and Ethics of Digital Photojournalism" The New York Times Feb.17,2015. https://lens.blogs.nytimes.com/2015/02/17/world-press-photo-manipulation-ethics-of-digital-photojournalism/ (accessed 14 January 2018).

Choa, M. et al. (2008). "The effectiveness of cardiopulmonary resuscitation instruction: Animation versus dispatcher through a cellular phone". Resuscitation. 77 (1): 87–94. doi:10.1016/j.resuscitation.2007.10.023. PMID 18164119.

Choa, M. et al. (2009). "Animation-assisted CPRII program as a reminder tool in achieving effective one-person-CPR performance".
Resuscitation. 80 (6): 6804. doi:10.1016/j.resuscitation.2009.03.019. PMID 19410356.

Christopoulos D.et al (2013) Digital Storytelling within Virtual Environments: "The Battle of Thermopylae". In: Pan Z., Cheok A.D., Müller W., Liarokapis F. (eds) Transactions on Edutainment IX. Lecture Notes in Computer Science, vol 7544. Springer, Berlin, Heidelberg https://doi.org/10.1007/978-3-642-37042-7_2

Dankbaar,M. et al.(2017)."Comparative effectiveness of a serious game and an e-module to support patient safety" knowledge and awarenessbiomedical central the open acesss BMC Med Educ. 2017; 17: 30.Published online 2017 Feb 2. doi: 10.1186/s12909-016-08365PMCID: PMC5289006https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5289006/

Datta. R. et al (2012). "Simulation and its role in medical education". Medical Journal Armed Forces India (MJAFI) Copyright © 2018 Elsevier Inc. All rights reserved. April 2012.Volume 68, Issue 2, Pages 167–172 DOI: https://doi.org/10.1016/S0377-1237(12)60040-9.

Djaouti, D. et al. (2015)."Classifying Serious Games: the G/P/S model" (PDF). Retrieved 26 June 2015. https://en.wikipedia.org/wiki/Serious_game(accessed in 20/2/2018)

Dykes,J.et al.(2005). "Exploring Geovisualization, Pergamon, Modelling Virtual Environments forGeovisualization: A Focus on Representation" 732pp. 0-08-044531-4 Pergamon, Elsevier Ltd. All rights reserved.

Farouk,A.(2011)."Mental Processes of Reading Instructional Illustrations In Non-Linear Interactive Sequential Art".11th International Educational Technology Conference 2011-Istanbul University-Turkey.

Farouk,A.(2017)."Visualizing Archaeological Illustrations between Aesthetic and Scientific Vision in Conserving Cultural Heritage."3rd International Conference on Plastic Arts and Community Service (Art and Identity between Heritage and Contemporareity) Faculty of Fine Arts in Luxor- South Valley University.

Fulcher, KL (1996). "The Jury as Witness: Forensic Computer Animation Transports Jurors to the Scene of a Crime or Automobile Accident". University of Dayton Law Review. 55: 56–76.

Gauthier,J.& Nachbar,M. (2005)."The Virtual Patient Project" www.tinkering.net/vp Funding for this research is provided in part by NYU's CDCF 2004-2005 grant.

Getting start with a 3D animated movie (2015). "Typical stages in 3D production pipeline(first part)" - Oct 14, 2015 https://sepxhan.wordpress.com/mud/get-start-with-a-3d-animated-movie/(accessed January 2018)

Giemsa, B. (2007)."Technical illustrations in 21st century , a primer for today's professionals", parametric technology co-operation (PTC) all rights reserved.https://mafiadoc.com

Gleicher, M.(1997)."Motion Editing with Spacetime Constraints. the Proceedings of the 1997 Symposium on Interactive 3D Graphics.

Gleicher,M.(1999). "Animation From Observation: Motion Capture and Motion Editing Computer Graphics" 33(4), p51-54. Special Issue on Applications of Computer Vision to Computer Graphics.

Hajar,R. (2011)."Medical Illustration: Art in Medical Education". Heart Views Apr-Jun; 12(2): 83–91 doi: 10.4103/1995-705X.86023

Hargreaves,K. (2018)."A Beginner's Guide to User Experience (UX) Fundamentals
https://generalassemb.ly/design/visual-design/user-experience-fundamentals (accessed 9 February 2018).

Hartog, Casper (2009)."Scenario design for serious gaming Guiding principles for the design of scenarios and curricula in military Job Oriented Training". delft university of technologtno Faculty of Technology, Policy & Management .

Herron, Jennifer (2016) Augmented Reality in Medical Education and Training, Journal of Electronic Resources in Medical Libraries, 2016 - Taylor & Francishttps://scholarworks.iupui.edu

Hybrid medical animation.(2018). "Transforming your science into a technically-accurate, visually-dramatic experience". http://www.hybridmedicalanimation.com/work/illustration/© 2018 Hybrid Medical Animation. (accessed 9 February 2018).

Interrante, V. (2005), "Art and science in visualization". In Visualization HandbookElsevier Inc.. DOI: 10.1016/B978-012387582-2/50042-3 (2005). pp. 781-805.

Ivan. Viola & E.Gröller (2005) :"Smart Visibility in Visualization , Computational Aesthetics in Graphics, Visualization and Imaging" , L. Neumann, M. Sbert, B. Gooch, W. Purgathofer

IV. Alexandrova et al (2011)."Animations of Medical Training Scenarios in Immersive VirtualEnvironments"Digital Media and Digital Content Management (DMDCM) 12123929.DOI: 10.1109/DMDCM.2011.64. IEEE Hangzhou, China.http://www.kyb.tuebingen.mpg.de/fileadmin/user_upload/files/publications/2011/CASA-2011-Alexandrova.pdf

J. Diepstraten et al.(2003)."Interactive Cutaway Illustrations". Computer graphics forumVolume 22, Issue 3September 2003 Pages 523–532© The Eurographics Association and John Wiley & Sons Ltd.First. published: September 2003.DOI: 10.1111/1467-8659.t01-3-00700.

John, M.(2010)."3-D visualization and animation technologies in anatomical imaging".Journal of anatomy.v.216(2); 2010 FebPMC2815947Published online 2009 Nov 25. doi: 10.1111/j.1469-7580.2009.01165.x

Kathleen R.(2008). "The history of medical simulation". Journal of Critical Care. 23 (2): 157–66. doi:10.1016/j.jcrc.2007.12.004. PMID 18538206

Komura,T.(2006)."Computer Animation" Lecture 6. "Motion Editing"
http://homepages.inf.ed.ac.uk/tkomura/cav/presentation6.pdf.(acessesed 14 January 2018)

Kononowicz, A.et al. (2015)."Virtual patients - what are we talking about? A framework to classify the meanings of the term in healthcare education". BMC Medical Education. 15:11. doi:10.1186/s12909-015-0296-3.

ISSN 14726920. PMC 4318546 PMID 25638167 https://en.wikipedia.org/wiki/Virtual_patient accessed 20 february 2018

Lai-Chu, et al (2011). "Animation program used to encourage patients or family members to take an active role for eliminating wrong-site, wrong-person, wrong-procedure surgeries: Preliminary evaluation". International Journal of Surgery. 9 (3): 241–7. doi:10.1016/j.ijsu.2010.11.018. PMID 21167326.

Lugmayr, A.et al. (2016). "Serious storytelling - a first definition and review". Multimedia Tools and Applications. doi:10.1007/s11042-016-3865-5.

https://en.wikipedia.org/wiki/Serious_game(accessed in 20/2/2018).

Lyttle ,M. (2015)."Debating the Rules and Ethics of Digital Photojournalism"The New York Times Feb. 17, 2015 https://lens.blogs.nytimes.com/2015/02/17/world-press-photo-manipulation-ethics-of-digital-photojournalism/ (accessed 14 January 2018).

M. Jung et al. (2000). "Motion Capture and Editing: Bridging Principles and Practices", A K Peters, Ltd.

Masson, T. (1999). "CG 101: A Computer Graphics Industry Reference". Digital Fauxtography Inc. ISBN 0-7357-0046-X.

Matt, (2016)."why is medical3d-animationbetter?" 3D Animation for Healthcare Marketing. - All Rights Reserved© 2018 Medical 3D Animation Company Dallas | Scientific & Device https://medical3danimationcompany.com (accessed February 2018)

McNally, M. (2015)."Debating the Rules and Ethics of Digital Photojournalism".The New York Times Feb. 17, 2015 https://lens.blogs.nytimes.com/2015/02/17/world-press-photo-manipulation-ethics-of-digital-photojournalism/ (accessed 14 January 2018)

Medical animation.(2018).http://trinityanimation.com/medical-animation(accessed February 2018).

Mike, M.(1993). "The Magic of Image Processing". Sams Publishing , USA.

Mikkel, A. & Rudolph, B.(1992). "Digital Photography" . Random House, New York.

Minhua M. et al. (2014)."Virtual, Augmented Reality and Serious Games for Healthcare"Springer Science & Business library of congress , newyork1 April 25, 2014.

Mitra, N. J. et al. (2010): "Illustrating How Mechanical Assemblies Work", ACM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH 2010 Volume 29 Issue 4, July 2010.

Mocappy(2018)."4 step motion editing workflow: how to edit motion and create characters"by mocappyhttp://mocappys.com/4-step-motion-editing-workflow-how-to-edit-motion-and-create-characters/#.wltp2k6wbiu (accessed January 2018)

Oai A. H. & Ning F. (2013)."Computer Simulation and Animation in Engineering Mechanics: A Critical Review and Analysis".120thASEE Paper ID #6516 Annual conference and exposition. Atlanta American Society for Engineering Education, 2013

https://www.asee.org/public/conferences/20/papers/6516/download(accessed February 2018)

Patrick, M. (2018)."Simulation and animation have similarities and differences"
https://www.fayengineering.com/articles/simulation-and-animation(accessed February 2018)
Parent,R.(2012). "Computer Animation: Algorithms and Techniques".
Ohio: Elsevier. ISBN 978-0-12-415842-9.
Rick , De Mott. (2006). Mova Contour Moves "Motion Capture To Reality Capture" Monday, July 31, 2006 Animation World Networkhttps://www.awn.com/news. (accessed February 2018)
S. de Ribaupierre, et al. (2014)."Healthcare Training Enhancement Through Virtual Reality and Serious Games."Chapter 2. springer www.springer.com ISBN 9783642548154-
Santo,H. (1993). "Edugraphics '93" : First International Conference on Graphics Education. Lisbon: Association for Computing Machinery.
https://en.wikipedia.org/wiki/Serious_game(accessed in February 2018).
Sheba,G. et al (2013). "Using Animation as an Information Tool to Advance Health Research Literacy among Minority Participants"AMIA Annu Symp Proc. 2013: 475–484.PMCID: PMC3900192 Published online 2013 Nov 16
Stephen,M. et al. (2005)."Medical-legal Illustrations, Animations and Interactive Media: Personal Injury Lawyers' Perceptions of Effective Attributes"The Journal of Biocommunication (JBC).Volume 31, Issue 3, ISSN: US0094-2499.Produced in the U.S.A. 2005 .The Journal of Biocommunication, Inc. All rights reserved.www.jbiocommunication.org/issues/31-3/pdf/Mader-Medical_Legal_Illustration
Steven M. et al. (2003). "Motion sketching for control of rigid-body simulations transactions on graphics". vol. 22, no. 4, october 2003, pages 1034–1054.
Stokowski Laura A.,(2013) A Digital Revolution: Games, Simulations, and Virtual Worlds in Nursing Education https://www.medscape.com/viewarticle/780819_4(accessed in February 2018).
Thalmann , D. (2001). "The Role of Virtual Humans in Virtual Environment Technology and Interfaces" Computer Graphics Lab", EPFL, Lausanne, Switzerland Frontiers of Human-Centered Computing, Online , 2001 - Springer
https://link.springer.com/content/pdf/10.1007/978-1-4471-0259-5_3.pdf
Tsafrir,J. (2001). "Medical illustration: from caves to cyberspace"Health Information & Libraries Journal.Volume 18, Issue 2 pages 99-109 doi 10 1046/j.1471-1842.2001.d01-16.x
Weber,S.(2002)."Media and the construction of reality.What does "media construct reality" mean?" From an ontological to an empirical understanding of construction.original version [german]: Stefan Weber: Was heißt "Medien konstruieren Wirklichkeit"? Von einem ontologischen zu einem empirischen Verständnis von Konstruktion. (Medienimpulse,Heft Nr. 40, Juni 2002) publisher: www.mediamanual.at, BMBWK, Abt. Z/11 Medienpädagogik, Bildungsmedien, Medienservice, Minoritenplatz 5, A-1010 Wien
Wettlaufer, A. K.(2003). "In the mind's eye : the visual impulse in Diderot, Baudelaire and Ruskin", pg. 257. Amsterdam: Rodopi. (http://en.wikipedia.org/wiki/Perception). (accessed in February 2018)

