Multimedia

Lecture 1

Introduction to multimedia.
Fields in the multimedia domain.
Market applications and educational tools

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Important:

- Laboratory classes
  - 14 topics, grades for each topic
  - Last week: reserve
  - Only 3 absences/failing grades allowed
- Test: (penultimate lecture)
  - 60 minutes, 9 questions (answers to be written; webcam required), 5 points each. If test passed (1/2 points or more), 1/3 of points is added to points scored from lab. classes

Important:

- Laboratory topics
  1. Digital sound editing, music for illustrating multimedia applications (A.Pietruszko)
  2. Image processing (M.Mazur)
  3. Photography, digital effects. Still image compression (M.Mazur)
  4. Moving pictures compression (M.Mazur)
  5. Augmented Reality (***)
  6. PowerPoint (A.Wieczorkowska)
  7. Sound analysis (M.Dębski)
  8. Speech synthesis - TTS and ASR (P.Pawłowski)
  9. 3D modelling, MagicaVoxel (P.Pawłowski)
  10. Virtual Reality tours, Theasys (***)
  11. Adobe Premiere – film editing (P.Pawłowski)
  12. Animate (P.Pawłowski_Eng/A.Wołk_Pol)
  13. After Effects (M.Mazur)
  14. HTML5 and web page (P.Pawłowski_Eng/A.Wołk_Pol)
- Teachers assigned to topics, not to groups
- One week for completing the tasks (holidays: extended)
  - If later -> lower grade (unless sick note/quarantine)

Important:

If test failed: final grade 3,

unless attendance and activity of students at lectures is good, and then, final grades are:

- 39...<52.5: 3
- 52.5...<59.5: 3.5
- 59.5...<66.5: 4
- 66.5...<74: 4.5
- 74 and above: 5

- Points can be gained if students actively participate in lectures

Last week

- 21-23 June 2023

Outline

- Introduction
- Elements of multimedia
  - Compression
- Applications
- References

Introduction

- Multimedia
  - Combines many types of media
  - It is interactive, involving the user in selection and control
- Applications
  - Business services: training, presentations, general communications
  - Educational tools; encyclopedias
  - Entertainment; games

Multimedia systems

- Interdisciplinary aspects of multimedia
  - Telecommunications, electronics, hardware/software
- Quality of service - quality-controllable services
    - Scaling and adaptation of media quality
    - Resource reservation
  - Heterogeneous requirements coming from different distributed applications
    - Service and protocol requirements, processing constraints
    - quality layering; error control
  - “real-time” process – delivers results in a given time span
    - E.g. video – presented neither too quickly nor too slowly
  - hard deadlines (should not be violated), soft deadlines (failing does not produce unacceptable results – reference points with a tolerance)

Multimedia systems

- Multimedia operating systems
  - Memory management, device management
  - Scheduling; resource requirements negotiations
    - Hierarchical scheduling; real-time scheduling
  - Reservation-based systems and adaptation-based systems
    - Reservation-based systems provide timing guarantees even in overload situations; assume timing constrains specification and admission control to provide and enforce a requested resource allocation
    - Adaptation-based systems provide the best possible timing guarantees, but in case of scarce resources, achieve dynamic re-allocation of resources and deliver graceful degradation for MM applications; require only importance information (weight), upon which metric the resource is allocated
      - Throughput and delay guarantee; bandwidth allocation; priorities; fair queueing; quality measurements

Multimedia systems

- Media servers – multimedia file servers
  - Storage: disks; disk controllers (e.g. RAID – Redundant Arrays of Inexpensive Disks; http://en.wikipedia.org/wiki/RAID - levels; mirroring) and disk management
  - file systems (e.g. FAT – File Allocation Table)
- Networks; Internet
  - Technologies (e.g. Ethernet, ATM cells – asynchronous transfer mode)
  - Services, protocols, layers
- Communication and group communication
  - Protocols, TCP/IP etc.
  - Multicast Backbone (MBone) – multicast transmission over the Internet: set of multicast routers
  - Conferences – synchronous telecooperation
    - Streaming

Multimedia systems

- Synchronization
  - Hard sync, soft sync (audio and video; lip sync); sync over reference points; clock sync
  - MHEG (Multimedia and Hypermedia information coding Expert Group, ISO/IEC JTC1/SC29/WG12)
  - Time-specific Petri networks
    - A transition fires when there is a non-blocking token in all input places
    - When a transition fires, the token is removed from all input points and placed to the output lines
    - Once a token was placed to a new place, it is blocked for as long as it remains in this place
      - E.g. slide show, 3s/slide
  - Sync. in interactive multimedia
  - Computer clocks can be synchronized with an Internet time server
    - Network Time Protocol - NTP

R.Steinmetz, K.Nahrstedt: Multimedia Systems. Series: X.media.publishing Springer, 2004
K.Jeffay, H.Zhang: Readings In Multimedia Computing And Networking. Elsevier.

Media networks

Technology	Purveyor	Date intro	Synchronization	Transport
Ravenna	ALC NetworX	2012	IEEE 1588-2008	RTP
AVB	mIEEE, AVnu	2011	IEEE 1588-2008 advanced profile (IEEE 802.1AS)	Ethernet, RTP
Q-LAN	QSC Audio	2009	IEEE 1588-2002	UDP
N/ACIP	EBU	2007	Data packet arrival times	RTP
Dante	Audinate	2006	IEEE 1588-2002	UDP
Wheatnet-IP	Wheatstone	2005	Proprietary	RTP
LiveWire, +	Telos/Axia	2004	Proprietary	RTP

Table 1. Existing network technologies, listing their sync and transport methods (courtesy Kevin Gross)

- protocols for carrying audio based on IP
  - J. Audio Eng. Soc., Vol. 62, No. 3, 2014, p.190
- AVB: Audio-Video Bridging
  - Ordinary IP switches don't know whether packets carry audio data. AVB compliance brings the ability for devices to recognize media packets. AVB is an enhancement to Ethernet that introduces stream reservation and device synchronizations
- AES67-2015 standard for network audio interoperability (JAES 65(1/2), 2017)
  - based on RTP (Realtime Transport Protocol), which itself is based on UDP (User Datagram) and IP
  - transport of packets uses IP version 4; packet duration of 1 ms
  - basic IEEE1588 sync (https://www.ravenna-network.com/aes67/what-is-aes67-1/)
- Telecoms solutions have largely given way to IP-based data communications systems as the predominant way to implement media networks, and this brings with it the challenges of ensuring a high quality of service for real time data
  - J. Audio Eng. Soc., Vol. 60, No. 4, p.286, JAES 67(3) p. 145

Data embedding and watermarking

- Watermarking: information hiding
- Transparent data: embedding, watermarking for audio, image, video
  - Embed text, binary streams, audio, image, video in a host audio, image, video signal
  - Perceptually inaudible or invisible, to maintain quality of the source data
  - E.g. multilingual sound tracks in a movie, copyright protection

Elements of multimedia

- text,
- graphics (including 3D graphics),
- animation,
- video,
- sound,
- Internet, hypertext, hotspots,
- interaction with the user
  - interfaces
  - selection of an object and control (rotation etc.)

Text: cognition and brain

- **Aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe**
  - http://www.mrc-cbu.cam.ac.uk/people/matt.davis/Cmabrigde/

Graphics

- Raster graphics, vector graphics
- Image information coding
- Compression
- Properties of our sight are used in efficient lossy coding of graphical information

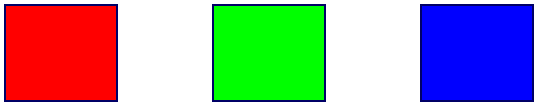
- 3D Graphics

Standards of graphics compression

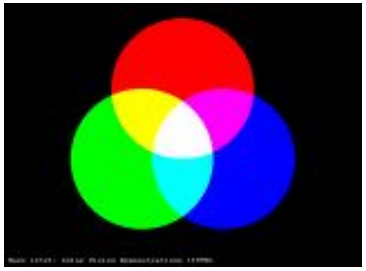
- Lossless and lossy compression
  - GIF - *Graphics Interchange Format* (LZW – *Lempel, Ziv, Welch* – „dictionary" algorithm)
  - JPEG – *Joint Photographic Expert Group* – quality/size
    - change RGB -> YCrCb (luminance/chrominance)
    - Lossy compression bases on DCT – *Discrete Cosine Transform*
    - Lossless compression – Huffman coding (probabilistic)
  - Fractal compression
  - Wavelet based compression

Colors

- Monitors – additive color mixing (white=all basic colors mixed)
  - RGB (*Red-Green-Blue*) (sRGB – standard RGB) http://dret.net/glossary/srgb



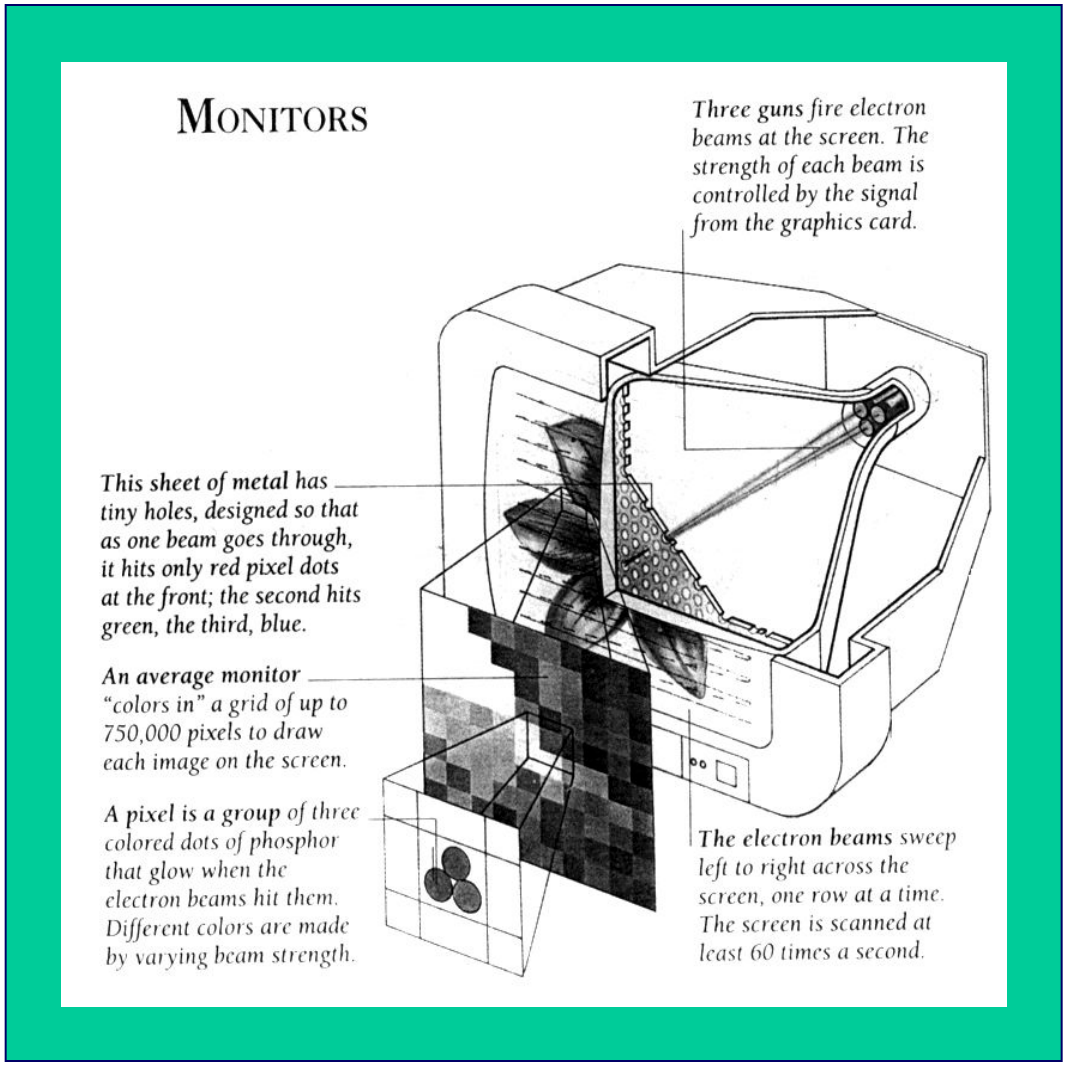
- Print – subtractive color mixing (white=no basic colors)
  - CMYK (*Cyan-Magenta-Yellow-Black*)



http://psych.hanover.edu/JavaTest/Media/Chapter6/MedFig.ColorMixer.html
http://www.colortools.net/color_mixer.html

Graphics - display

CRT

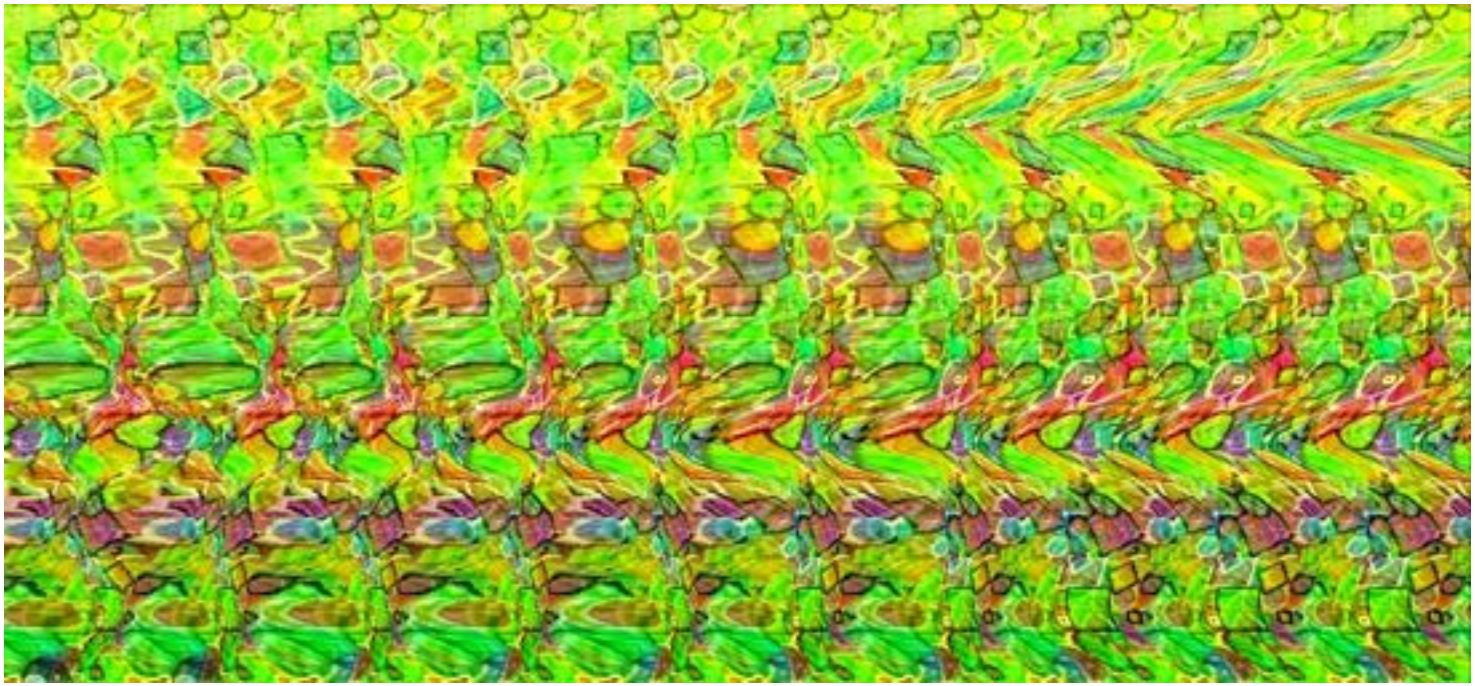


- LCD
- Projectors

Graphics and our senses

- Properties of our sight are used to present 3D information in the screen

http://psych.hanover.edu/Krantz/art/index.html



Depth cues – see links:

- Disparity https://psych.hanover.edu/Krantz/art/cues.html
  - 2 images taken from a slightly different position
- Interposition https://psych.hanover.edu/Krantz/art/inter.html
  - partial overlapping of objects
- Relative height - horizon line https://psych.hanover.edu/Krantz/art/rel_hgt.html
- Relative size https://psych.hanover.edu/Krantz/art/rel_size.html
  - object smaller on the retina when farther away
- Linear perspective https://psych.hanover.edu/Krantz/art/linear.html
  - parallel lines get closer in the scene
- Texture gradient https://psych.hanover.edu/Krantz/art/texture.html
  - farther, texture gets finer
- Shadow. Aerial perspective – blueing, slight blurring https://psych.hanover.edu/Krantz/art/aerial.html

Graphics

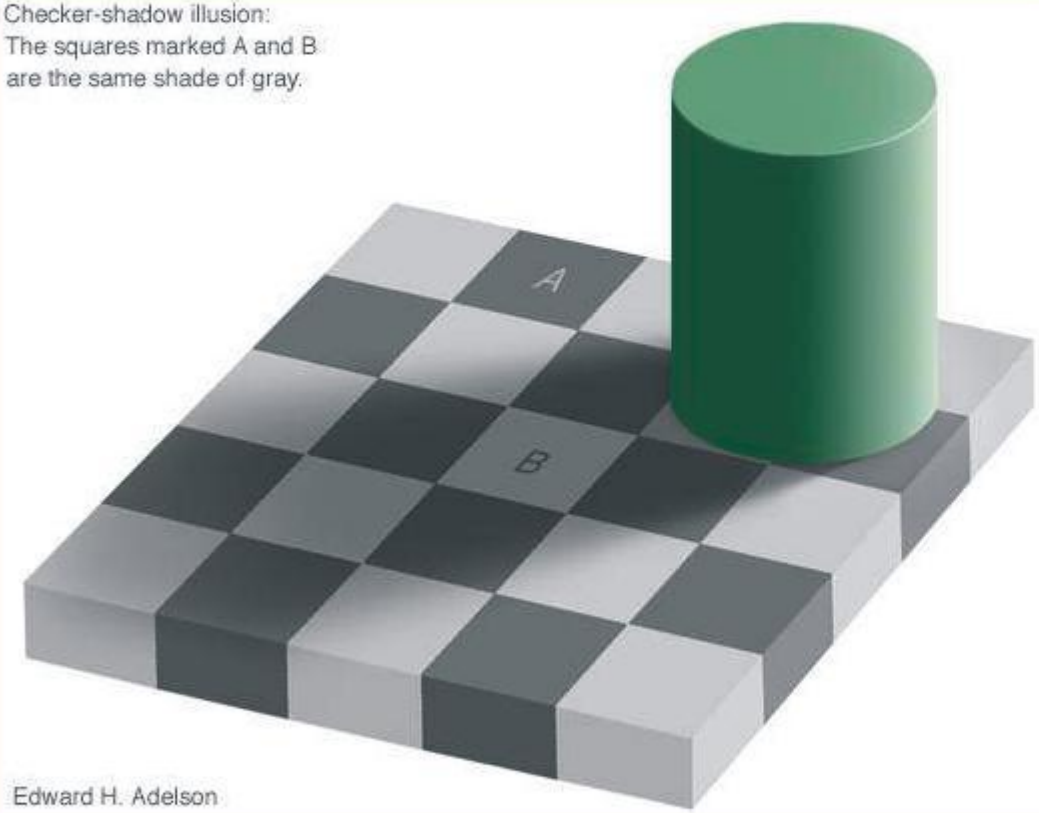
Corel PHOTO-PAINT 12 - Bitmap in Graphic1.CPT

File Edit View Image Effects Mask Object Movie Web Tools Window Help

100% Mode

Bitmap in Graphic1.CPT (24-Bit RGB) @100% - Background

Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.



Edward H. Adelson

Image Info

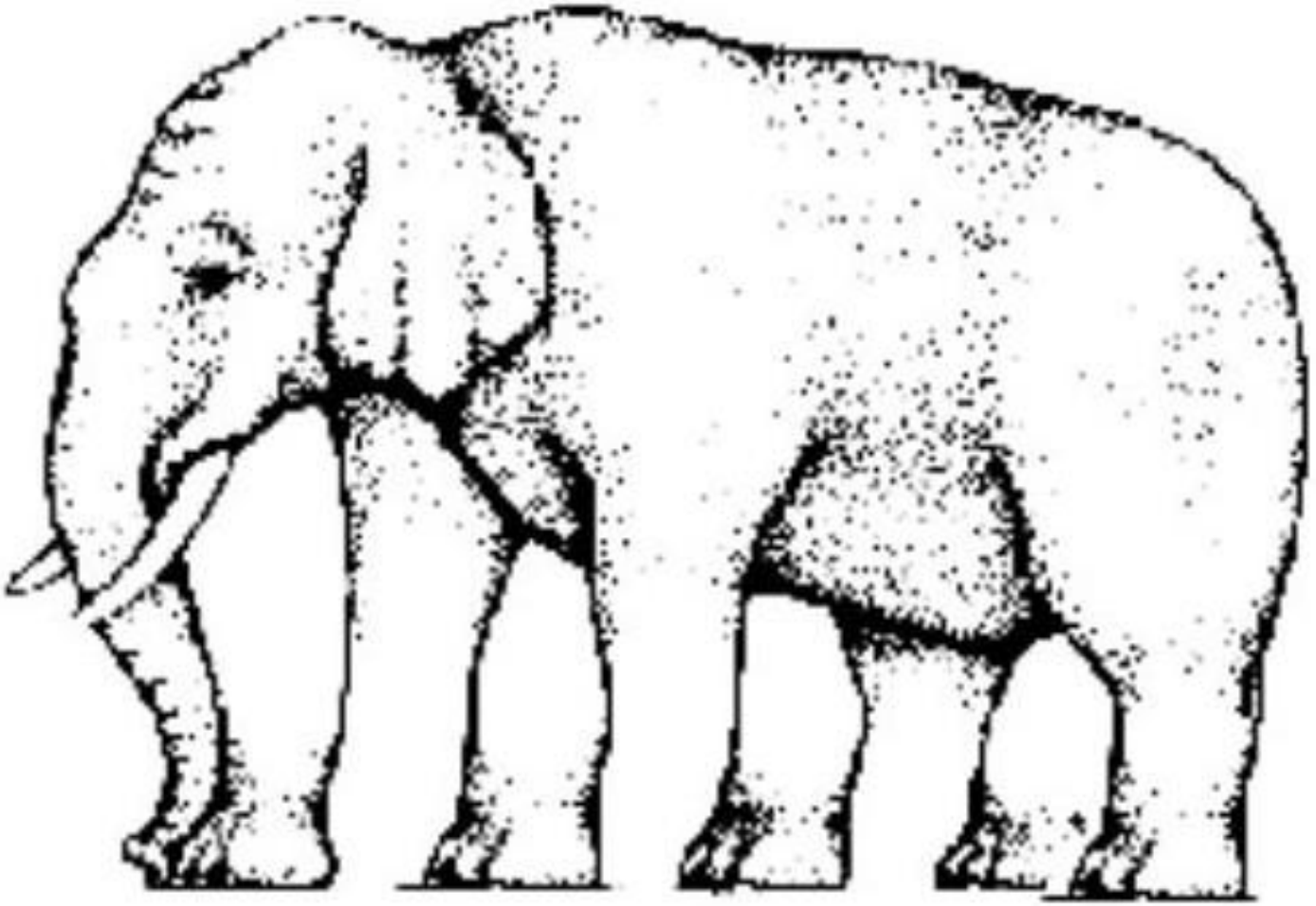
RGB 107, 107, 107
Hex 6B, 6B, 6B
CMYK 57, 47, 47, 4

X: 101,9528 W:
Y: 54,6805 H:

Objects Image Slicing Color Image Info

File Size: 162 KB Click object to select

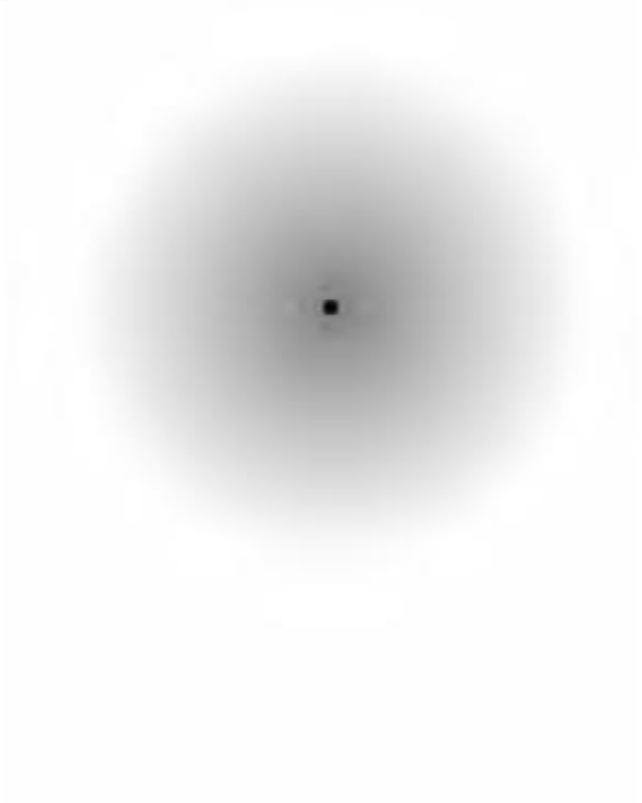
Graphics and our senses



How many legs does this elephant have?

Graphics and our senses

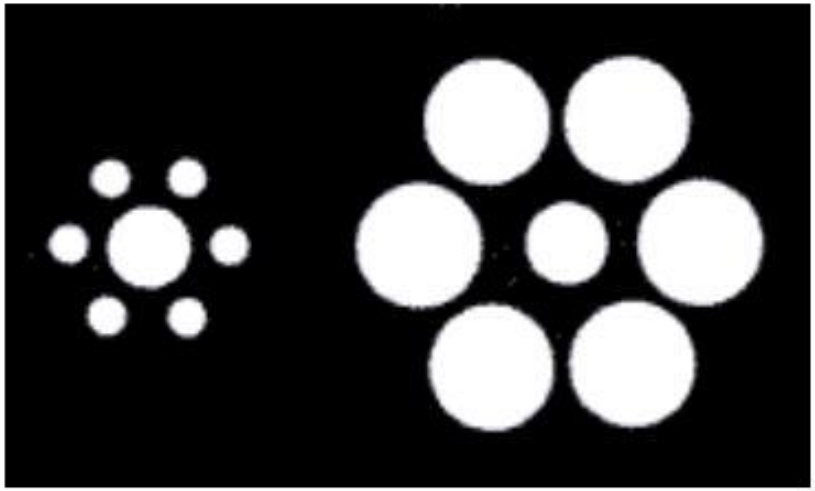
Keep staring at the black dot. After a while the gray haze around it will appear to shrink.



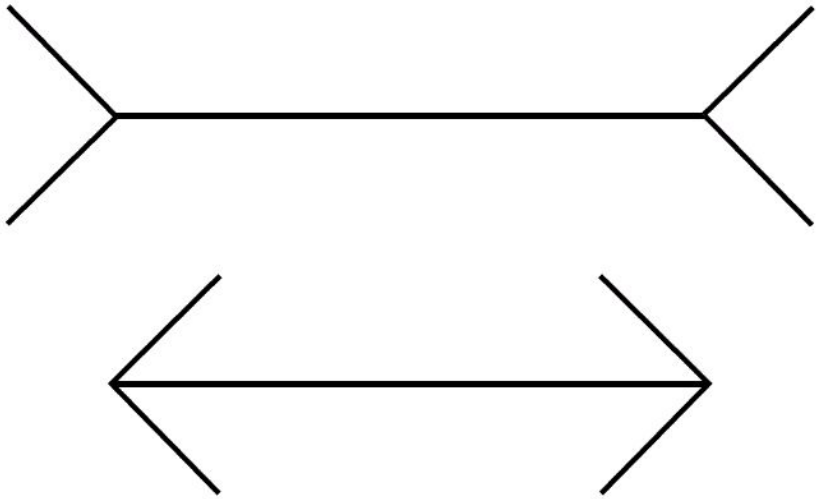
Graphics and our senses

Graphics and our senses

Is the left center circle bigger?

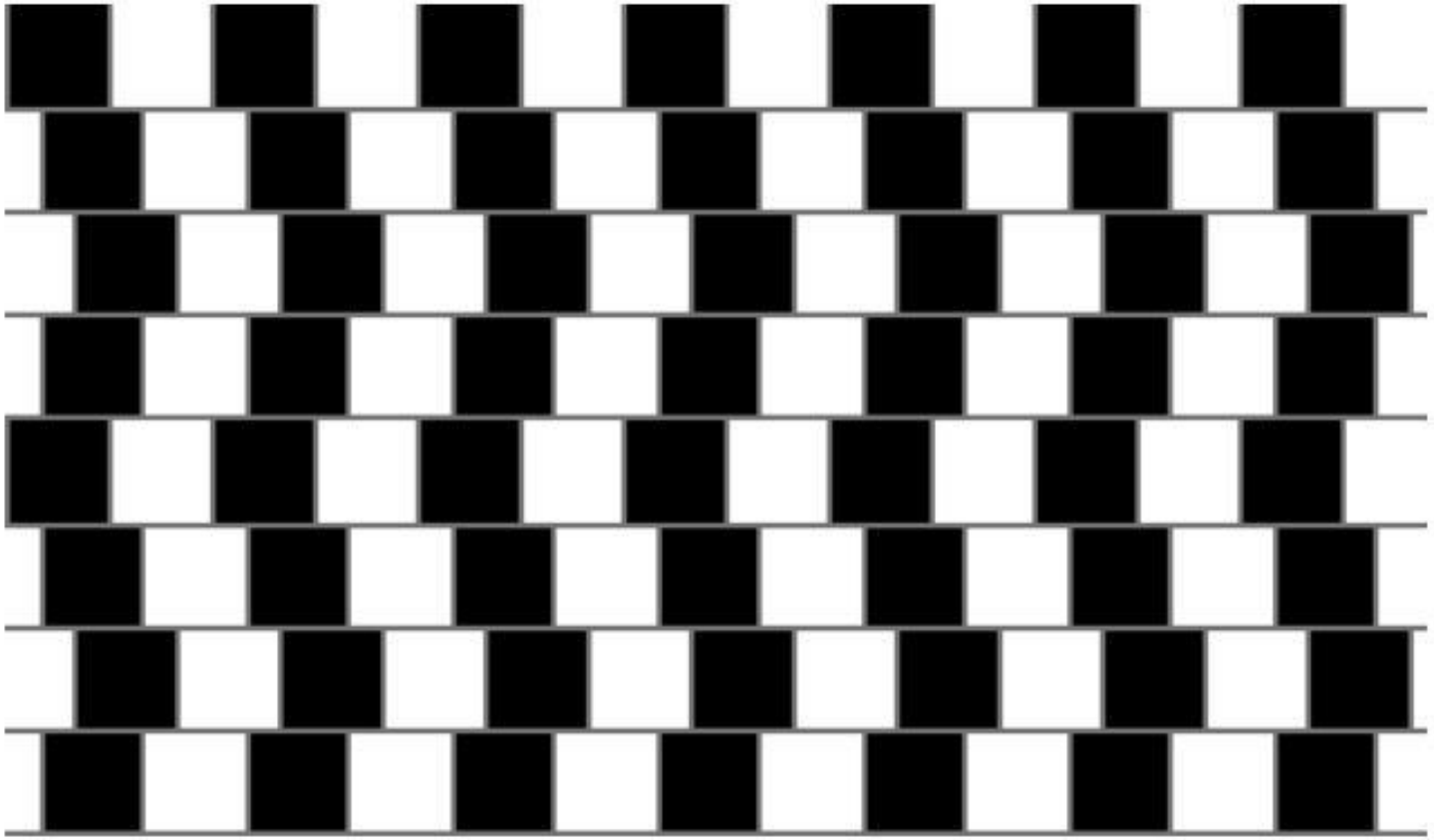


No, they're both the same size



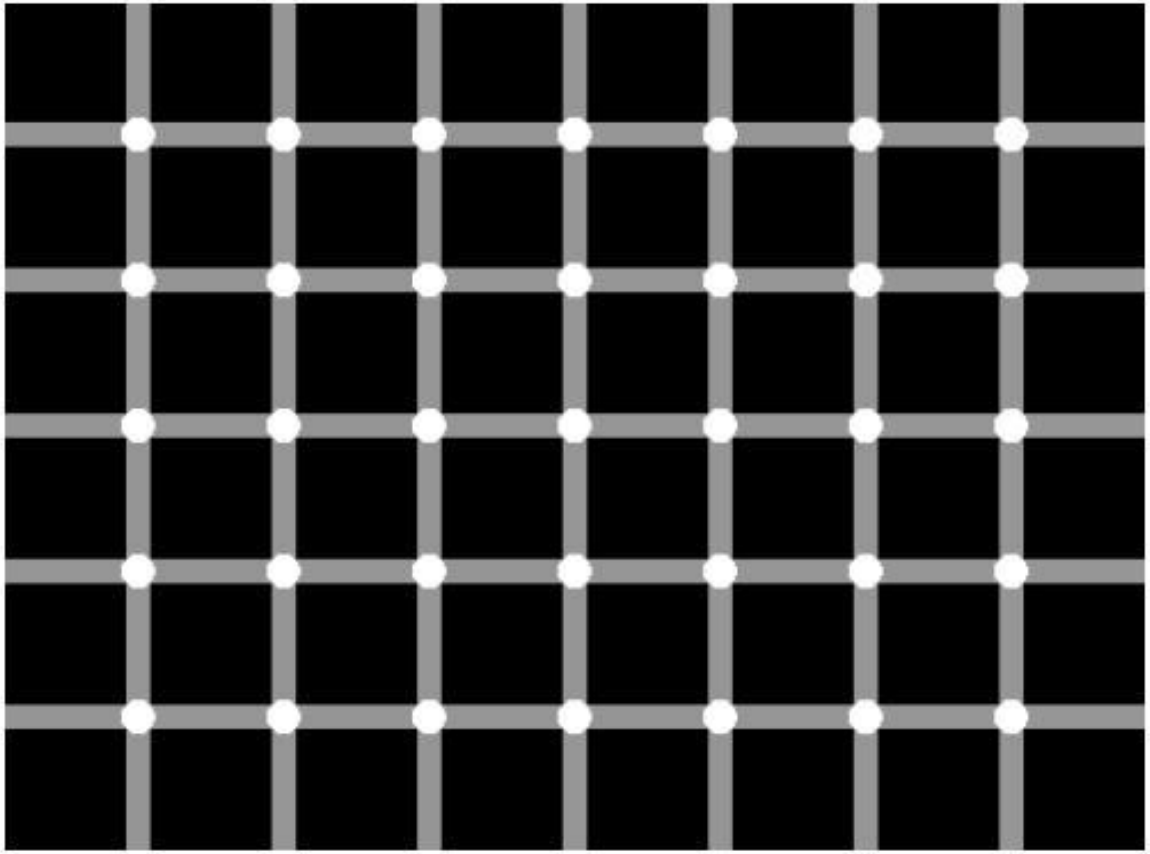
Müller-Lyer illusion

Graphics and our senses



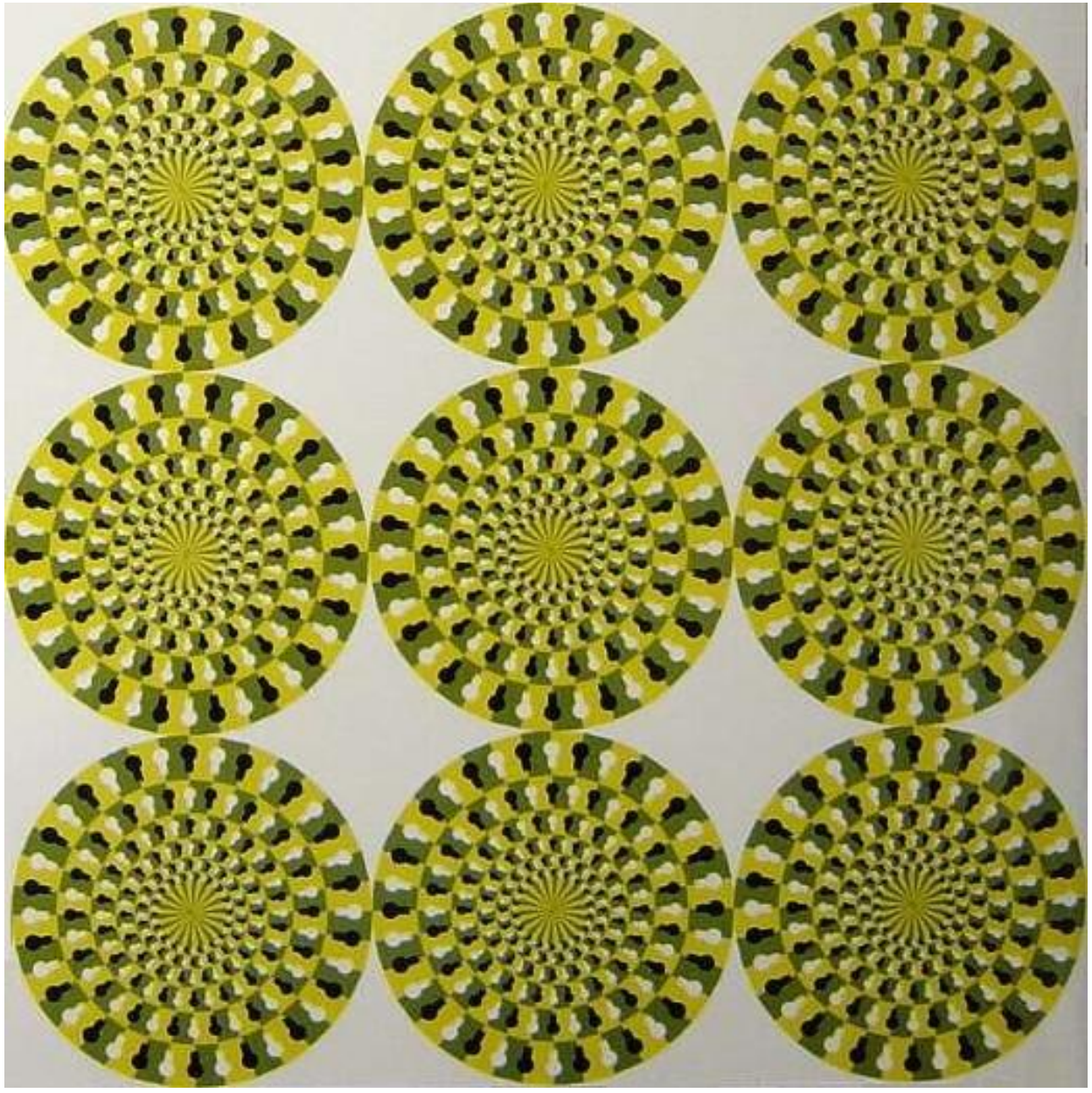
Are the horizontal lines parallel or do they slope?

Graphics and our senses

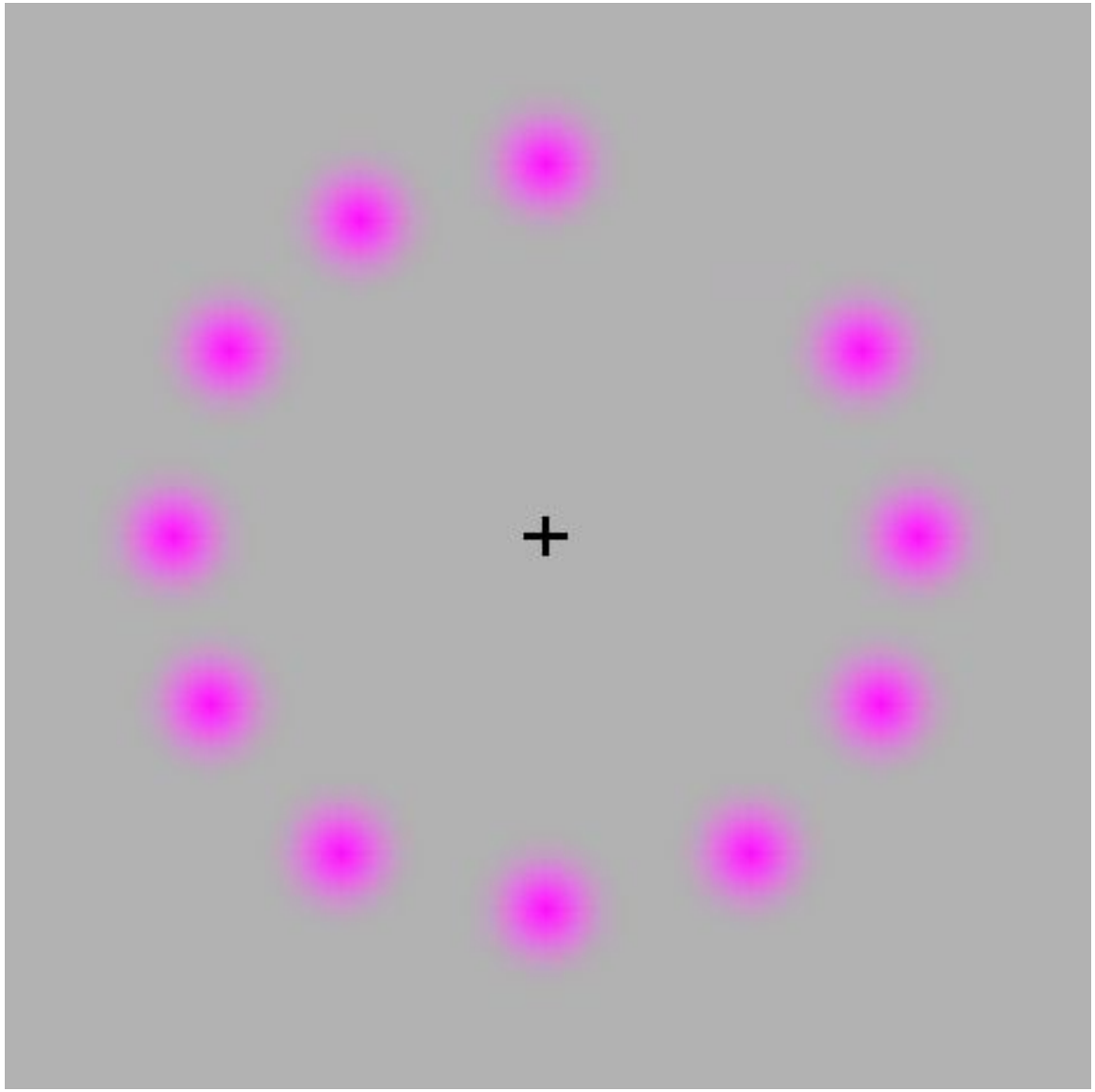


Count the black dots! :o)

Graphics and our senses



Graphics and our senses



3D

- Depth: interocular distance – 2 images presented to 2 retinas (disparity)
  - 3D displays create the illusion of depth by presenting a different image to each eye
  - Filtered lenses (anaglyph): red-blue, red-green, magenta-cyan glasses; picture contains 2 differently filtered colored images, 1 for each eye
  - Active shutter glasses: glasses rapidly switch between black and clear using a pair of low-latency transparent LCD screens
    - synchronizing device often used to coordinate the signals from the other components of the display

3D

– Autostereoscopic display - group of pixels has its light directed to one eye, and another group to the other

- parallax barrier: a series of slits in the display, precisely placed to allow light from every other line of pixels to go one way or the other
  http://techcrunch.com/2010/06/19/a-guide-to-3d-display-technology-its-principles-methods-and-dangers/

Illusions

- Motion aftereffect http://en.wikipedia.org/wiki/Motion_aftereffecthttp://en.wikipedia.org/wiki/Motion_aftereffect, http://psych.hanover.edu/JavaTest/Media/Chapter1/MedFig.MotionAfterEffect.html
  - experienced after viewing a moving visual stimulus for a time (seconds to minutes) with stationary eyes, and then fixating a stationary stimulus
  - The stationary stimulus appears to move in the opposite direction to the original stimulus
    - http://psych.hanover.edu/JavaTest/Media/Chapter7/MedFig.SpiralAftereffect.html
- Tetris effect (named after the video game) - can occur with any prolonged visual task and in other sensory modalities
  - have the images, catchy tune to play out unbidden in one's mind, sea legs (move with an unbidden rocking motion)

Animation and video

- Simple animation - gif

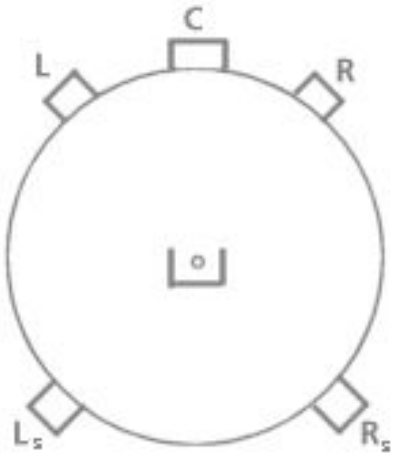
- software-based animation
- movies

Video coding

- Similarity of neighboring frames is used
- Similarity of neighboring fragments in a frame is used
- Compression standards
  - MPEG
  - MJPEG

Sound

- Stereo and surround sound
  - 5.1 system
    - Full-band channels: L, R, C, LS, RS
    - Subwoofer 20-120Hz
- Digital sound recording
  - formats



Sound

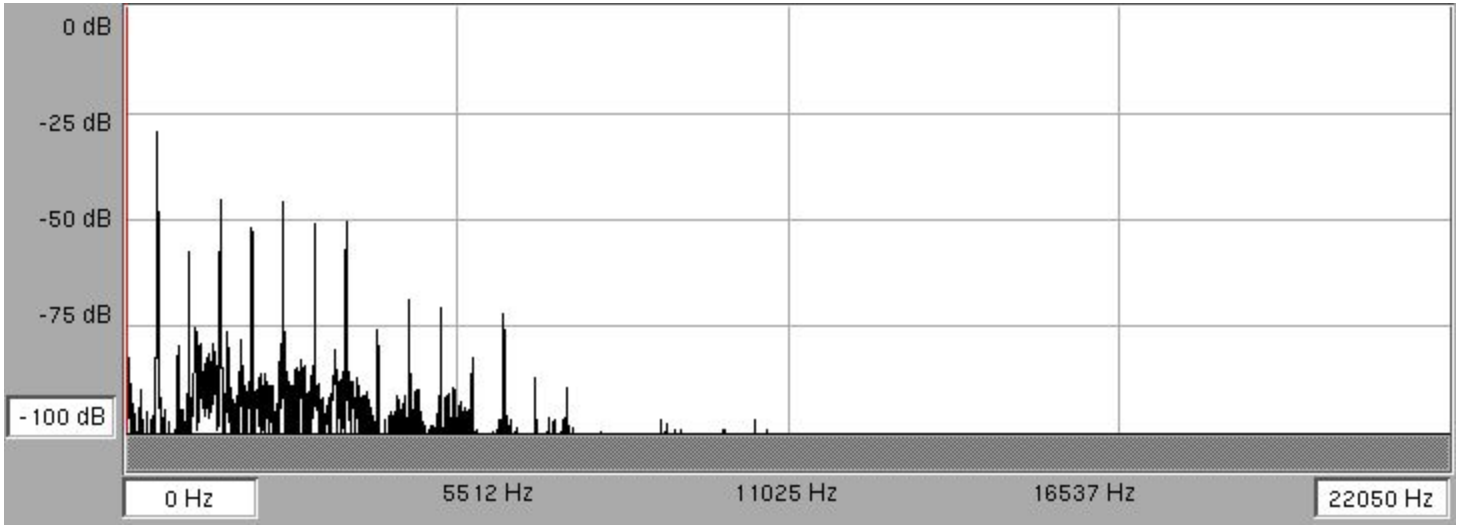
- Digital recording and sound coding
  - High quality recording
  - Lossy coding, using properties (imperfections) of human hearing
    - Standards MPEG (*Moving Pictures Experts Group)*
- Formats
  - wav, au, snd, mp3

Standards MPEG

- MPEG-1
  - Sampling rates
    - 32kHz (digital audio broadcasting DAB)
    - 44.1kHz (CD)
    - 48kHz (digital audio tape DAT)
  - Layer I: bit rate 192kB/s (for single channel of CD quality)
  - Layer II: 128kB/s
  - Layer III: 64kB/s
- MPEG-2
  - More channels (for 5.1)
  - 8kB/s, halves of sampling frequencies
- MPEG-4 and MPEG-21
- MPEG-7 (multimedia content description)

Sound analysis - FFT

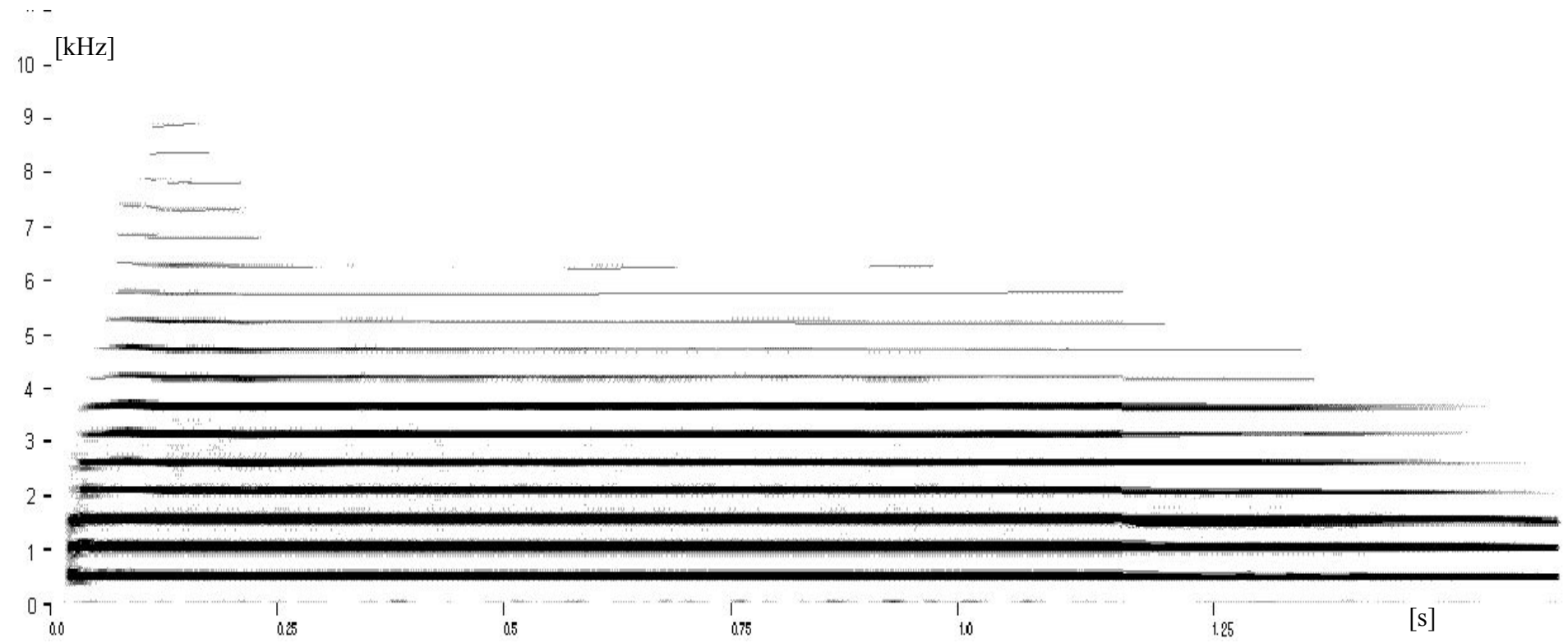
- Fast Fourier Transform



spectrum

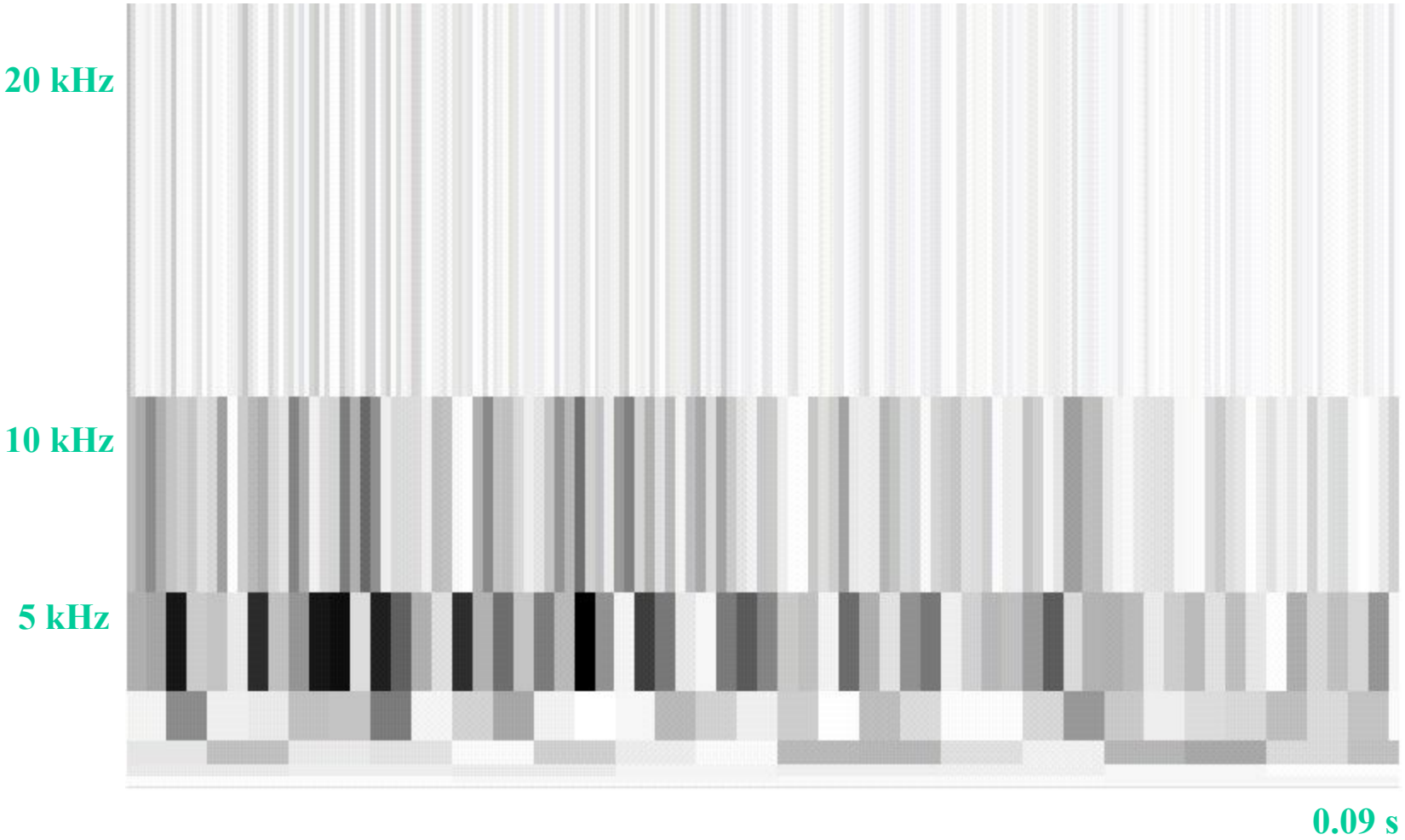
(clarinet, c^2, 523.3 Hz)

Sound analysis - Sonogram - FFT



sonogram (trumpet, c^2, 523.3 Hz)

Sound analysis - Wavelet analysis



frame 4096 samples
sampling frequency 44.1kHz

Internet, hypertext, hotspots

- www
  - URL – Uniform Resource Locator
    - http, ftp
- Navigating through information
- Working with multimedia encyclopedias – seeking information
- Hypertext – can be created using any text editor
  - SGML, Standard Generalized Markup Language, technology used in applications such as HTML
    - XML – simplified SGML
  - HTTP, Hypertext Transfer Protocol
    - CSS – cascading style sheets – design (templates to declare HTML elements)

URI

- Uniform Resource Identifier - standard defined in RFC 2396
  - a string of characters used to identify a name or a resource on the Internet
- Schemes specifying a concrete syntax and associated protocols define each URI
- One can classify URIs as locators (URLs), or as names (URNs), or as both
  - URL (Uniform Resource Locator)
  - URN (Uniform Resource Name)
  - A URL is a URI that, in addition to identifying a network-homed resource, specifies the means of acting upon or obtaining the representation: either through description of the primary access mechanism, or through network "location"

https://www.iana.org/assignments/uri-schemes/uri-schemes.xhtml

Hypermedia

- Dexter Hypertext Reference Model
  - Provides a facility for creating links within a document, with the links being anchored inside document components
    - Notions of links, anchors and components
- Amsterdam Hypermedia Model framework – adding time and context to the Dexter Model
  - Extends Dexter model by adding to it the notions of time, high-level presentation attributes and link context
    - A portion of this extension is on the basic aspects of the CMIF (CWI Multimedia Interchange Format) multimedia document model
      - (CWI - Centrum voor Wiskunde en Informatica)
- Hypertext Design Model (HDM)
  - General purpose model for authoring-in-the-large – allows the description of overall classes of information elements and navigational structures of complex applications without much concern with implementation details, and in a system-independent manner

WWW

- HTML – Hypertext Markup Language
- XML – eXtended Markup Language
  - Meta language allowing the design of an own markup language and user-defined document types for the Web
- XHTML - eXtensible HyperText Markup Language
  - reformulation of HTML 4.0 as an XML 1.0 application
  - provides framework for future extensions of HTML, aims to replace HTML in the future http://www.xhtml.org/
- Dynamic documents
  - Dynamic HTML – Java extensions to HTML; Java Applets; JavaScript
    - Introduced synchronization support into Web documents
  - Common Gateway Interface CGI – interface to programs that run on a server, so that a user can interact with that program: the user can start a program on the server and wait for a response from the server
  - ActiveX by MS; components can be written in programming languages (e.g. C, VB), the use of ActiveX controls in HTML pages requires a script language (e.g. JS, VBS)

WWW

- W3C working group on synchronized MM developed a language for Web-based Multimedia presentations, SMIL (Synchronized Multimedia Integration System)
  - SMIL takes information objects encoded using individual formats (such as HTML for text, AIFF for audio or MPEG for video) and combines them into a presentation
  - Temporal specifications, spatial specifications (primitives for layout control), alternative behaviour specifications (primitives to express the various optional encodings within a document based on systems or user requirements) and hypermedia support (mechanisms for linking parts of a presentation)
  - GRiNS – a GRaphical INterface for creating and playing SMIL documents
    - Logical structure view, virtual timeline view, presentation view; playout engine

Semantic web

- RDF (Resource Description Framework) – semantic web standard
  - standard model for data interchange on the Web
  - RDF Specification consists of a suite of W3C Recommendations, published in 2004
- RDF has features that facilitate data merging even if the underlying schemas differ, and it specifically supports the evolution of schemas over time without requiring all the data consumers to be changed
- RDF extends the linking structure of the Web to use URIs to name the relationship between things as well as the two ends of the link (this is usually referred to as a “triple”)
  - using this simple model, it allows structured and semi-structured data to be mixed, exposed, and shared across different applications
- Other technologies, like OWL (Web Ontology Language, http://www.w3.org/TR/owl-features/) or SKOS, build on RDF and provide language for defining structured, Web-based ontologies which enable richer integration and interoperability of data among descriptive communities

http://www.w3.org/RDF/

GRDDL

- GRDDL ('griddle') is a markup format for Gleaning Resource Descriptions from Dialects of Languages
  - It's a way of extracting Semantic Web data in RDF from XML formats (especially XHTML dialects or microformats) via transformations identified by URIs and typically expressed in XSLT
- W3C Recommendation
- enables users to obtain RDF triples out of XML documents, including XHTML

http://www.w3.org/2003/g/data-view

Internet: multimedia file formats

- Graphics: GIF, JPEG
- Sound: WAV (Windows), AU (Unix), AIFF (Macintosh), MIDI, MP3 etc.
- Video: avi, mpeg, mov, qt, rm, DivX etc.

Interaction with the user

- Interfaces
  - Usability engineering
- Tactile devices (haptic technology)
- Speech recognition
  - Kinect for Xbox/Windows: microphone array, speech translation, speech-to-text

Interaction with the user

- Motion sensing
  - Nintendo Switch Pro Controller, JoyCon; motion sensing in 3D (accelerometer and gyroscope); tactile feedback
  - Sony's PS Move, DualSense: IMU (Inertial Sensor Unit) 3-axis linear accelerometer and a 3-axis angular rate sensor; wand's position is tracked by PS Eye or PS Camera; haptic feedback
  - Kinect: Azure Kinect – AI sensors; 12MP RGB camera + 1MP depth camera for body tracking of multiple skeletons; image categorization; accelerometer and gyroscope

Applications – industries

- Computing
- Telecommunications
- Publishing
- Consumer audio-video electronics
- Television/movie/broadcasting

- Research examples (MIT): HCI (Human-Computer Interaction), sensing, affective computing and ethical computing, space tech, cross-disciplinary: science and arts, medical research

Multimedia applications

- Database systems – MM database management systems assure:
  - Data security and integrity in case of errors
  - DB query and output
- Data modeling
  - Temporal and spatial data; metadata
- Media servers – handle media data, especially continuous (analog) data

Multimedia applications

- Programming
  - Many functionalities (esp. time-critical ones) have usually been written in conventional procedural programming languages (e.g. C)
  - MM-specific functions (adjusting volume etc.) are often called or controlled via hardware-specific libraries
  - Some applications are implemented by use of *tools*
    - integrate the device units into the corresponding application
  - Device drivers, system software (e.g. MS DirectX – suite of MM application programming interfaces APIs built into MS Windows; access to specialized hardware features without having to write hardware-specific code);
  - Authoring systems
  - Very large data volumes, real-time requirements, data streams, sync
  - Java; object-oriented frameworks

Multimedia applications

- Security
  - To prevent potential attacks on comp., stored and transmitted data, and communication relationships
    - Net/application level; cryptographic methods
- Failure safety
  - Limit or reduce the impact of inadvertent events that can lead to a failure of or damage comp./data/comm.
  - Data protection, recovery, improvement of a computer's failure safety

Multimedia applications

- Fault tolerance and speed are the most critical aspects
  - Conventional data (control info, metadata) must be delivered in a reliable fashion, to assist A-V data
  - Elements of MM must be synchronized

Multimedia applications

- Security – e.g. pay TV systems (broadcasting – unidirectional, conference systems)
  - Legal data protection
    - Connection to copyright
  - Organizational d.p.
    - four-eye principle: some activities may only be executed in the presence of at least 2 persons; 2 passwords)
  - Technical d.p.
    - network layer – protocols, firewalls, packet filters, router configuration
    - application layer – interests of users: protection measures against external and internal abuse
      - Access protection against unauthorized inspection, authenticity – proof of the originality of the data material or a communication relationship, confidentiality preventing unauthorized third parties from reading data, integrity – correctness and completeness of stored and transmitted data, nonrepudiation –acceptance of the origin and the receipt,
      - Transparent representation possibilities – try&buy transactions
      - Copyrights
      - Privacy and anonymity – protection of personal data

Multimedia applications - security

- Security – cryptography: cryptographic algorithm/cipher/encryption method is a mathematical function used to encrypt and decrypt data
  - Symmetric or private key system – communicating parties use the same secret key
  - Asymmetric or public key system – pair of keys: one is known to both communicating parties, and the other key is known only to one of the parties
  - Partial encryption – only sections of the entire data volume of a message are encrypted
  - Video/audio encryption

Multimedia applications - security

- Digital signatures – offer verifying both the authenticity and integrity of a message
- Steganographic methods for AV data– integrate the copyright info into the data in a way that is invisible to the user
  - Digital watermarks: the key required to reproduce the copyright info is deposited with a trusted authority, so that irregularities or disputes about copyrights can be settled by reading out the copyright info from the material
    - For content protection – prevention of illegal copying
  - Digital fingerprints – designate what type of info is embedded (the way how this info is embedded is similar to the common d.w. algorithms)

Applications: Equipment

- Multimedia computer
  - PC
  - Mac
  - Mobile platforms
- Software
  - *plug-ins*
  - Web browsers, search engines
  - Java etc.

Equipment

- Digital and analog equipment
  - DVD, Blu-ray
  - Video equipment
  - speakers, headphones, monitors etc.
  - Internet
  - Mobile devices, wireless networks

Multimedia applications

- Design
  - Visualizations
  - Symbols: logos, icons, pictograms – visual labels
  - Illustrations
- User interfaces
  - Components: buttons, menus, dialog boxes, windows, audio
  - Navigation; scrollbars
  - Interaction
    - Virtual reality, augmented reality
  - Esthetics
  - User-friendly
  - Usability - kansei

Multimedia applications

- Media preparation – from physical into electronic data: audio, video, text, graphics and still image, 2D and 3D motion
- Media editing – word processing, image and graphic editing, animations, audio and video editing
- Media integration
  - MM editors; WYSIWYG
  - Hypermedia/Hypertext editors
  - Authoring tools
- Media transmission
  - Interaction: dialog between users, messaging, queries
  - Distribution – services: pay-per-view, video-on-demand
- Media usage
  - e-books and magazines, kiosks, tele-shopping, entertainment (virtual reality, interactive video and audio – VoD, streaming audio; computer games)

Who uses multimedia?

- Commercial applications - companies
  - Presenting information to the public
    - Points-of-sale kiosks
  - Personnel training
  - Promotion
  - General communications
- At home
  - Entertainment and education, „intelligent” home appliances
    - games
- Multimedia learning

Commercial applications

- Interactive TV
- Virtual supermarkets
- In-flight multimedia
  - Passengers can chart the fight on the screen
  - Films on demand
- Information
  - kiosks: *touch screens*
- Videoconferencing

Multimedia at home

- Library on CD/DVD
  - Reference books (encyclopedias)
  - One-subject encyclopedias
  - Interactive books
  - Atlases, 3D atlases + video
    - Zooming in
    - Specific information about places

Multimedia at home

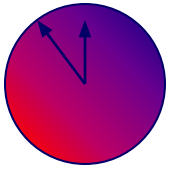
- Radio
  - http://www.rmf.fm/
- Internet newspapers
  - www.gazetawyborcza.pl/
- Interactive and virtual museums
  - http://ibiblio.org/wm/

Learning through play: *edutainment*

- Creativity
  - Creative writing
  - Cartoons, animation, sound
  - Living books – interactive versions of printed children's books
- Language-learning
  - Voice recognition
  - Grammar lessons (verbs: animation)

Learning through play: *edutainment*

- Math
  - Games with numbers
- Adventures in science (biology, physics)
  - Interactive inventions
- Early learning – preschool education
  - Clock, colors



Games and entertainment

- *shoot ‘em ups*
- Activity games – flying, driving
- Role-playing games
- Puzzle games

Games and entertainment

- Interactive films – actors directed by the player
- Interactive music – simulation of working in a recording studio
- Consoles

Virtual reality

- Computer graphics
- Video
- Stereo sound
- 3D display

Virtual reality - applications

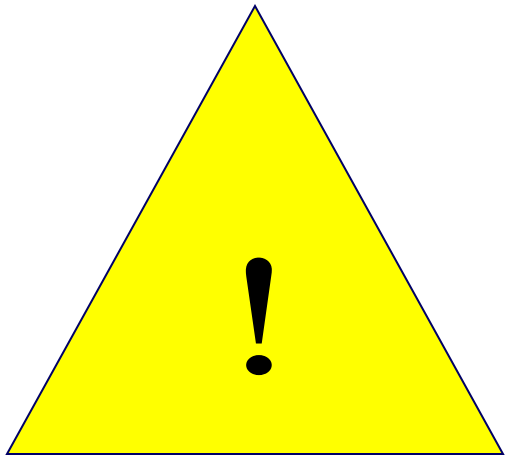
- Flight simulation
- CAD (*Computer-Aided Design*)
  - 3D virtual buildings
- Crash tests of cars
- Military training – battle simulation
- Games

- *Headset* – 2 screens, sound
- Treadmill

Health and safety

- The competitive nature of many computer games means that they can have an addictive, compulsive effect
- ENSURE THAT YOU DO NOT SIT IN FRONT OF THE COMPUTER SCREEN FOR EXTENDED PERIODS WITHOUT TAKING REGULAR BREAKS !!!

If half of your work time is with computer -> 5-min. break after 1 hr.



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