Augmented reality

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*Wikiude* World Browser on the *iPhone 3GS* uses GPS and a *solid state compass*

*AR Tower Defense* game on the *Nokia N95* smartphone (Symbian OS) uses *fiduciary markers*

**Augmented reality** (AR) is a term for a live direct or an indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input, such as sound or graphics. It is related to a more general concept called *mediated reality*, in which a view of reality is modified (possibly even diminished rather than augmented) by a computer. As a result, the technology functions by enhancing one’s current perception of reality. By contrast, *virtual reality* replaces the real-world with a simulated one.

Augmentation is conventionally in *real-time* and in semantic context with environmental elements, such as sports scores on TV during a match. With the help of advanced AR technology (e.g. adding *computer vision* and *object recognition*) the information about the surrounding real world of the user becomes *interactive* and digitally manipulable. Artificial information about the environment and its objects can be overlaid on the real world. The term augmented reality is believed to have been coined in 1990 by Thomas Caudell, working at Boeing.[2]
Research explores the application of computer-generated imagery in live-video streams as a way to enhance the perception of the real world. AR technology includes head-mounted displays and virtual retinal displays for visualization purposes, and construction of controlled environments containing sensors and actuators.

Contents

[hide]

- 1 Definition
  - 1.1 Taxonomy of Reality, Virtuality, Mediality
- 2 Examples
  - 2.1 Sports
  - 2.2 Other
- 3 History
- 4 Technology
  - 4.1 Hardware
    - 4.1.1 Display
      - 4.1.1.1 Head-mounted
      - 4.1.1.2 Handheld
      - 4.1.1.3 Spatial
    - 4.1.2 Tracking
    - 4.1.3 Input devices
    - 4.1.4 Computer
  - 4.2 Software and algorithms
- 5 Applications
  - 5.1 Applications as of 2011
  - 5.2 Potential applications
- 6 Notable researchers
- 7 Conferences
- 8 Software
  - 8.1 Free software
  - 8.2 Non-commercial use
- 9 Books
- 10 In popular culture
  - 10.1 Television & film
  - 10.2 Literature
  - 10.3 Games
  - 10.4 Comics
  - 10.5 Tools
- 11 See also
- 12 References

[edit] Definition

Ronald Azuma offered a definition in 1997.[4] Azuma's definition says that Augmented Reality combines real and virtual, is interactive in real time and is registered in 3D.

Additionally Paul Milgram and Fumio Kishino defined Milgram's Reality-Virtuality Continuum in 1994.[5] They describe a continuum that spans an entirely real environment to a purely virtual environment. In between are Augmented Reality (closer to the real environment) and Augmented Virtuality (closer to the virtual environment).
**[edit] Taxonomy of Reality, Virtuality, Mediality**

This continuum has been extended into a second dimension that incorporates *Mediality.*[^4] On a graph, the origin R at the bottom left denotes unmodified reality. A continuum across the Virtuality axis V includes reality augmented with additional information (AR), as well as virtual reality augmented by reality (Augmented Virtuality or AV). Unmediated AV simulations are constrained to match the real world behaviorally if not in contents.

The mediality axis measures modification of AV, AR and combination of these. Moving away from the origin on this axis, the depicted world becomes increasingly different from reality. Diagonally opposite from R are virtual worlds that have no connection to reality. (at right) It includes the virtuality reality continuum (mixing) but also, in addition to additive effects, also includes modulation and/or diminishment of reality. Mediation encompasses deliberate and/or unintentional modifications.[^citation needed]

**[edit] Examples**

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**[edit] Sports**

AR has become common in sports telecasting. The yellow "first down" line seen in television broadcasts of American football games shows the line the offensive team must cross to receive a first down using the 1st & Ten system. The real-world elements are the football field and players, and the virtual element is the yellow line, which augment the image in real time. Similarly, in ice hockey an AR colored trail shows location and direction of the puck. Sections of Rugby fields and cricket pitches display sponsored images.
Swimming telecasts often add a line across the lanes to indicate the position of the current record holder as a race proceeds to allow viewers to compare the current race to the best performance.

As an example of mediated (diminished) reality, the network may hide a real message or replace a real ad message with a virtual message.

[edit] Other

A museum exhibition might use projectors and screens to insert "objects" into the real environment. These objects relate to the particular location where they appear and can be interactive. [edit]

First-person shooter video games can simulate a player's viewpoint using AR to give visual directions to a location, mark the direction distance of another person who is not in line of sight and give information about equipment such as remaining ammunition. This is done using a virtual head-up display. [edit]

Heads-up displays in AR cars or airplanes are typically integrated into the windshield. [citation needed]

The F-35 Lightning II instead display information in the pilot's helmet mounted display, which allows the pilot to look through the aircraft's walls as if he was floating in space. [edit]

[edit] History

- 1957-62: Morton Heilig, a cinematographer, creates and patents a simulator called Sensorama with visuals, sound, vibration, and smell.[8]
- 1966: Ivan Sutherland invents the head-mounted display and positions it as a window into a virtual world.
- 1975: Myron Krueger creates Videoplace to allow users to interact with virtual objects for the first time.
- 1989: Jaron Lanier coins the phrase Virtual Reality and creates the first commercial business around virtual worlds.
- 1990: Tom Caudell coins the phrase Augmented Reality while at Boeing helping workers assemble cables into aircraft.[9]
- 1992: L.B. Rosenberg develops one of the first functioning AR systems, called VIRTUAL FIXTURES, at the U.S. Air Force Research Laboratory—Armstrong, and demonstrates benefits to human performance.[10]
- 1994: Julie Martin creates first Augmented Reality Theater production, Dancing In Cyberspace, funded by the Australia Council for the Arts, features dancers and acrobats manipulating body-sized virtual object in real time, projected into the same physical space and performance plane. The acrobats appeared immersed within the virtual object and environments. The installation used Silicon Graphics computers and Polhemus sensing system.
- 1998: Spatial Augmented Reality introduced at University of North Carolina at Chapel Hill by Raskar, Welch, Fuchs.[11]
- 1999: Hirokazu Kato (加藤博一) created ARToolKit at HITLab, where AR later was further developed by other HITLab scientists, demonstrating it at SIGGRAPH.
- 2000: Bruce H. Thomas develops ARQuake, the first outdoor mobile AR game, demonstrating it in the International Symposium on Wearable Computers.
- 2008: Wikitude AR Travel Guide launches on Oct. 20, 2008 with the G1 Android phone.[12]
2009: AR Toolkit was ported to Adobe Flash (FLARToolkit) by Saqoosha, bringing augmented reality to the web browser.[44]

[edit] Technology

[edit] Hardware

The main hardware components for augmented reality are: display, tracking, input devices, sensors and processor. These elements, specifically CPU, camera, display, accelerometer, GPS and solid state compass are often present in modern smartphones, which make them prospective AR platforms.

[edit] Display

There are three major display techniques for Augmented Reality are head–mounted displays, handheld displays, and spatial displays.

[edit] Head–mounted

A Head Mounted Display (HMD) places images of both the physical world and registered virtual graphical objects over the user's view of the world. The HMD's are either optical see–through or video see–through. Optical see-through employs half-silver mirrors to pass images through the lens and overlay information to be reflected into the user's eyes. The HMD must be tracked with sensor that provides six degrees of freedom. This tracking allows the system to align virtual information to the physical world. The main advantage of HMD AR is the user's immersive experience. The graphical information is slaved to the view of the user.[44]

[edit] Handheld

Handheld displays employ a small display that fits in a user's hand. All handheld AR solutions to date opt for video see-through. Initially handheld AR employed fiduciary markers, and later GPS units and MEMS sensors such as digital compasses and six degrees of freedom accelerometer–gyroscope. Today SLAM markerless trackers such as PTAM are starting to come into use. Handheld display AR promises to be the first commercial success for AR technologies. The two main advantages of handheld AR is the portable nature of handheld devices and ubiquitous nature of camera phones.

[edit] Spatial

Instead of the user wearing or carrying the display such as with head mounted displays or handheld devices; Spatial Augmented Reality (SAR) makes use of digital projectors to display graphical information onto physical objects. The key difference in SAR is that the display is separated from the users of the system. Because the displays are not associated with each user, SAR scales naturally up to groups of users, thus allowing for collocated collaboration between users. SAR has several advantages over traditional head mounted displays and handheld devices. The user is not required to carry equipment or wear the display over their eyes. This makes spatial AR a good candidate for collaborative work, as the users can see each other's faces. A system can be used by multiple people at the same time without each having to wear a head mounted display. Spatial AR does not suffer from the limited display resolution of current head mounted displays and portable devices. A projector based display system can simply incorporate more projectors to expand the display area. Where portable devices have a small window into the world for drawing, a SAR system can display on any number of surfaces of an indoor setting at once. The tangible nature of SAR makes this an ideal technology to support design, as SAR supports both a graphical visualisation and passive haptic sensation for the end users. People are able to touch physical objects, and it is this process that provides the passive haptic sensation. [45]
[edit] Tracking

Modern mobile augmented reality systems use one or more of the following tracking technologies: digital cameras and/or other optical sensors, accelerometers, GPS, gyroscopes, solid state compasses, RFID and wireless sensors. These technologies offer varying levels of accuracy and precision. Most important is the position and orientation of the user's head. Tracking the user's head(s) or a handheld input device can provide a 6DOF interaction technique.[11]

[edit] Input devices

Techniques include the pinch glove,[18] a wand with a button and a smartphone that signals its position and orientation from camera images.

[edit] Computer

The computer analyzes the sensed visual and other data to synthesize and position augmentations.

[edit] Software and algorithms

A key measure of AR systems is how realistically they integrate augmentations with the real world. The software must derive real world coordinates, independent from the camera, from camera images. That process is called image registration and is part of Azuma's definition of Augmented Reality.

Image registration uses different methods of computer vision, mostly related to video tracking. Many computer vision methods of augmented reality are inherited from visual odometry. Usually those methods consist of two parts. First detect interest points, or fiduciary markers, or optical flow in the camera images. First stage can use feature detection methods like corner detection, blob detection, edge detection or thresholding and/or other image processing methods.

The second stage restores a real world coordinate system from the data obtained in the first stage. Some methods assume objects with known geometry (or fiduciary markers) present in the scene. In some of those cases the scene 3D structure should be precalculated beforehand. If part of the scene is unknown simultaneous localization and mapping (SLAM) can map relative positions. If no information about scene geometry is available, structure from motion methods like bundle adjustment are used. Mathematical methods used in the second stage include projective(eppipolar) geometry, geometric algebra, rotation representation with exponential map, kalman and particle filters, nonlinear optimization.

[edit] Applications

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[edit] Applications as of 2011

Advertising: Marketers started to use AR to promote products via interactive AR applications. For example, at the 2008 LA Auto Show, Nissan unveiled the concept vehicle Cube and presented visitors with a brochure which, when held against a webcam, showed alternate versions of the vehicle.[18] In August 2009, Best Buy ran a circular with an augmented reality code that allowed users with a webcam
to interact with the product in 3D. In 2010 Walt Disney used mobile AR to connect a movie experience to outdoor advertising.

Task support: Complex tasks such as assembly, maintenance, and surgery can be simplified by inserting additional information into the field of view. For example, labels can be displayed on parts of a system to clarify operating instructions for a mechanic who is performing maintenance on the system. AR can include images of hidden objects, which can be particularly effective for medical diagnostics or surgery. Examples include a virtual X-ray view based on prior tomography or on real time images from ultrasound and microconfocal probes or open NMR devices. AR can enhance viewing a fetus inside a mother's womb. See also Mixed reality.

Navigation: AR can augment the effectiveness of navigation devices. For example, building navigation can be enhanced to aid in maintaining industrial plants. Outdoor navigation can be augmented for military operations or disaster management. Head-up displays or personal display glasses in automobiles can provide navigation and traffic information. Head-up displays are currently used in fighter jets. These systems include full interactivity, including gaze tracking.

Industrial: AR can be used to compare digital mock-ups with physical mock-ups for efficiently finding discrepancies between them. It can safeguard digital data in combination with existing real prototypes, and thus reduce the number of real prototypes and improve the quality of the final product.

Military and emergency services: Wearable AR can provide information such as instructions, maps, enemy locations, and fire cells.

Prospecting: In hydrology, ecology, and geology, AR can be used to display an interactive analysis of terrain characteristics. Users can collaboratively modify and analyze, interactive three-dimensional maps.

Art: AR can help create art in real time integrating reality such as painting, drawing and modeling. AR art technology has helped disabled individuals to continue pursuing their passion.

Architecture: AR can simulate planned construction projects.

Sightseeing: Guides can include labels or text related to the objects/places visited. With AR, users can rebuild ruins, buildings, or even landscapes as they previously existed.

Collaboration: AR can help facilitate collaboration among distributed team members via conferences with real and virtual participants.

Entertainment and education: AR can create virtual objects in museums and exhibitions, theme park attractions, games and books.

Performance: AR can enhance concert and theater performances. For example, artists can allow listeners to augment their listening experience by adding their performance to that of other bands/groups of users.

Translation: AR systems can provide dynamic subtitles in the user's language.

Potential applications

Possible extensions include:

- Devices: Create new applications that are physically impossible in "real" hardware, such as 3D objects interactively changing their shape and appearance based on the current task or need.
• **Multi-screen simulation:** Display multiple application windows as virtual monitors in real space and switch among them with gestures and/or redirecting head and eyes. A single pair of glasses could "surround" a user with application windows.

• **Holodecks:** Enhanced media applications, like pseudo holographic virtual screens and virtual surround cinema.

• **Automotive:** eye-dialing, navigation arrows on roadways

• "X-ray vision"

• **Furnishings:** plants, wallpapers, panoramic views, artwork, decorations, posters, illumination etc. For example, a virtual window could show a live feed of a camera placed on the exterior of the building, thus allowing the user to toggle a wall's transparency.

• **Public displays:** Window dressings, traffic signs, Christmas decorations, advertisements.

• **Gadgets:** Clock, radio, PC, arrival/departure board at an airport, stock ticker, PDA, PMP, informational posters/fliers/billboards.

• **Group-specific feeds:** For example, a construction manager could display instructions including diagrams at specific locations. Patrons at a public event could subscribe to a feed of directions and/or program notes.

• **Speech synthesis:** Render location/context-specific information via spoken words.

Augmented reality is one of the newest innovations in the electronics industry. It superimposes graphics, audio and other sense enhancements from computer screens onto real time environments. Augmented reality goes far beyond the static graphics technology of television where the graphics imposed do not change with the perspective. Augmented reality systems superimpose graphics for every perspective and adjust to every movement of the user's head and eyes.

- Development of the needed technology for augmented reality systems, however, is still underway within the laboratories of both universities and high tech companies. It is forecasted that by the end of this decade, the first mass-produced augmented reality systems will hit the market.

### Components of Augmented Reality

- The three basic components of an augmented reality system are the head-mounted display, tracking system and mobile computer for the hardware. The goal of this new technology is to merge these three components into a highly portable unit much like a combination of a high tech walkman and an ordinary pair or eyeglasses.

#### The Head-Mounted Display

- The head-mounted display used in augmented reality systems will enable the user to view superimposed graphics and text created by the system. As of today, the technology nearest to augmented reality head mounts is one that is being used in virtual reality applications.

- There are two basic head mount design concepts that are being researched for augmented reality systems and these are the video see-through systems and optical see-through systems.

- The video see-through systems block out the user's view of the outside environment and play the image real time through a camera mounted on the head gear. The main problem with this type of system is the delay in image adjustment whenever the user moves his head.

- Optical see-through systems, on the other hand, make use of technology that "paints" the images directly onto the user's retina through rapid movement of the light source. Though this system has its drawbacks, particularly its high price, researchers are confident that this system will be a lot more portable and less conspicuous for future augmented reality systems.

#### Tracking and Orientation

- Another component of an augmented reality system is its tracking and orientation system. This system pinpoints the user's location in reference to his surroundings and additionally tracks the user's eye and head movements. The complicated procedure of tracking overall location, user movement and adjusting the displayed graphics needed are some of the major hurdles in developing this technology. So far, the best systems developed still presents a lag or a delay between the user's movement and the display of the image.
• **Portable Computer**
  Last but not the least; augmented reality systems will need highly mobile computers. As of now, available mobile computers that can be used for this new technology are still not sufficiently powerful to create the needed stereo 3-D graphics. Graphics processing units like the NVidia GPU by Toshiba and ATI mobility 128 16MB-graphics chips are however being integrated into laptops to merge the current computer technology to augmented reality systems.

• **Applications of Augmented Reality Systems**
  The potential uses of augmented reality systems in everyday living and in various fields are many. Once available in the market, augmented reality systems will change the way people see and learn from their surroundings. Following are several applications for augmented reality systems.

• **Gaming and Entertainment**
  Augmented reality systems can be used to enhance gaming and entertainment. RPG games in the future can be integrated with augmented reality systems to give the user real environments as backdrops for his game and to make the user's senses perceive that he truly is one of the characters in the game. Sports fans will have access to up to date game information and enhanced sports viewing at home.

• **Education**
  Augmented reality systems in combination with other technologies such as WiFi could also be used to provide instant information to its users. For educational purposes, augmented reality systems can be used to view a panoramic recreation of a historical event superimposed on its real-time background. Students could use this system to have a deeper understanding on things like the formation of clouds, the structure of the universe and the galaxy, etc. through realistic and easily understandable augmented reality systems simulations.

• **Security and Defense**
  The military, particularly the Office of Naval Research and Defense Advanced Research Projects Agency or DARPA, are some of the original pioneers of augmented reality systems. One of the main uses of augmented reality systems to the military is providing field soldiers crucial information about their surroundings as well as friendly troops and enemy movements in their particular area. Augmented reality systems will also play a big role in law enforcing and intelligence agencies. This system will enable police officers to have a complete and detailed view and information about a crime scene, a patrol area, or a suspect line up.

• **Medicine**
  Medically, augmented reality systems could be used to give the surgeon a better sensory perception of the patient's body during an operation. This will result in less risky and more efficient surgical operations. The system could also be used in conjunction with other medical equipments such as an x-ray machine or an MRI to instantly give the doctors the information they need to make a medical diagnosis or decision.

• **Business**
  The building and construction field will benefit from the easier project management that augmented reality systems will bring. Markers can be placed or attached to a particular object a person is currently working on so that project and site managers can monitor work in
progress. In the petroleum and mining industry, it will enable decision makers to make timely
decisions. The management can decide about how ore will be mined by merely looking at the
superimposition of field data fed by the geological survey team through the augmented reality
systems.

- Augmented reality systems can be used in almost any field or industry. The novelty of instant
information coupled with enhanced perception will ensure that augmented reality systems will
play a big role in how people live in the future.

Mobile Augmented Reality Contact Lenses

Mobile Augmented Reality in Contact Lenses?

Mobile augmented reality contact lenses may do more that improve your sight.
Someday they could replace your mobile phone and let you communicate visually
anywhere in the world, improve your health and make virtual reality real. Perhaps
your ophthalmologist could perform Lasik surgery, burning a wireless circuit into
your cornea?

MobiHealthNews’ Brian Dolan, who was interviewed recently on
MobileBeyond, just wrote an amazing article called “Contact Lens: Future Platform
for mHealth.”

New Wireless Contact Lens Technology

Babak Parviz at the University of Washington in Seattle, is working on a contact lens
technology that could revolutionize wireless health monitoring and mobile
applications for your iPhone. But don’t stop there…

Babak Parviz’ lenses become biosensors that monitor internal body functions. While
the prototype version of the lens is powered by radio waves beaming electricity to a
loop antenna embedded in the contact lens, Parviz thinks a mobile phone or solar cells
(wireless electricity) could generate power for the lenses.
Here’s a video explaining the technology:

Parviz believes his contact lens development platform could emulate the iPhone’s on a smaller scale. Each lens at present only uses one LED. But he thinks with multiple LED’s embedded in the lens, application developers could write wireless monitoring “apps,” like the iPhone model, expanding the lens’ wireless health monitoring capabilities. Doctors, for example, could monitor their patient’s vital signs or blood sugar levels or blood pressure remotely.

**HUD’s (Heads-Up Displays) and Augmented Reality**

Parviz’ vision may come from science fiction writer and mathematician Vernor Vinge, who imagines computers in clothing and locational sensors placed elsewhere—a world of text and virtual objects overlaying our view of reality. Perhaps a pair of virtual reality goggles for Christmas? Or an augmented reality app for your next birthday present?

HUD’s or heads-up displays, used by fighter and space shuttle pilots, provide a glimpse into a world where our vision is augmented by sensory feedback.

Here’s an augmented reality video of an F16 pilot’s view of reality in an actual jet flight. (He gets quite a work-out as you can tell from his heavy breathing. Tough job flying jets these days.)

**Augmented Reality Contact Lenses**

Imagine in the not-too-distant future…

You’re wearing your iCon wireless lenses which are connected to your mobile carrier. Using augmented reality software embedded in the lenses, you make a video call to your friend in Australia by visualizing her in your brain. Your iCon and carrier initiate the call and connect you to your friend who’s also wearing an iCon. Both of you see and hear each other as if you were sitting next to each other in 3D virtual reality.

Driving in your car, wearing your [GPS-enabled iCon lenses](https://www.google.com), you connect to a Google server and a GPS satellite. You request mapping and directional information by voice which immediately appears on your iCon lenses. While driving, you see an overlay of roads, streets and arrows. A pleasant voice guides you safely and quickly to your destination. That’s mobile security.

You need cash. As you stand in front of your bank’s ATM machine, an optical device scans your iCon lenses, containing personal financial information stored on a memory chip. After verifying your identity, you communicate by voice with your ATM. “Need $40 cash, pronto.” An ATM voice thanks you and spits out the cash. Mobile commerce at its best.

Before leaving your doctor’s office, after having a physical, your physician puts two iCon lenses in your eyes to monitor your blood pressure and heart rate wirelessly.
You saunter out of the office feeling in control, augmented in an interactive wireless world.

Your teacher or instructor gives you a pair of wireless contacts containing your next lesson—“The sex life of the Fruit Fly.” As you sleep, the lesson downloads into your brain’s cortex. The ultimate mobile learning app.

Forget the contacts. How about your eye doctor using lasik surgery to burn augmented reality into your cornea?

Want more? Welcome to the mind of Nash’s World, who suggests other ways wireless contacts and other technologies could make your reality even more augmented.

First, a YouTube video showing a kid buying Lego toys with the help of a mirror in a store. Good augmented reality software tool:

Nash’s ideas:

- Bookstores will have the top 5 reviews hover above any book you take off the shelf (Forget the New York Times Book Review)
- Showing relationship status above our heads so we can date new people (The ultimate in mobile dating)
- A system will analyze body language of another so the socially awkward will receive cues on how to better communicate with the opposite sex (Poor eyesight? Put on those virtual reality goggles again)
- See how many calories something has before you eat it (Throw away your smartphone’s food calorie app)
- Be aware of the average crime rate of the area you are in by the color of the road (This one is sorta mixed reality)
- ...Watch tv from anywhere with images filling up [your] whole field of vision

**Abstract:**
TECHNOLOGY is advancing at an ever increasing rate and many are predicting the future gadgets that should soon be available; including Augmented Reality (AR) Contact Lenses.

They will have minuscule nano-circuitry implanted into them which will allow users to experience an ‘enhanced reality’.

Nanotechnology advances could allow small enough image sensors to be imbedded in the lenses, which would turn them into a camcorder and camera,
which when combined with the motion sensing rings on fingers would allow you to capture the shots and scenes.

*Lenses that monitor eye health are on the way, and in-eye 3D image displays are being developed too – welcome to the world of augmented vision*

THE next time you gaze deep into someone's eyes, you might be shocked at what you see: tiny circuits ringing their irises, their pupils dancing with pinpricks of light. These smart contact lenses aren't intended to improve vision. Instead, they will monitor blood sugar levels in people with diabetes or look for signs of glaucoma.

The lenses could also map images directly onto the field of view, creating head-up displays for the ultimate augmented reality experience, without wearing glasses or a headset. To produce such lenses, researchers are merging transparent, eye-friendly materials with microelectronics.

In 2008, as a proof of concept, Babak Parviz at the University of Washington in Seattle created a prototype contact lens containing a single red LED. Using the same technology, he has now created a lens capable of monitoring glucose levels in people with diabetes.

It works because glucose levels in tear fluid correspond directly to those found in the blood, making continuous measurement possible without the need for thumb pricks, he says. Parviz's design calls for the contact lens to send this information wirelessly to a portable device worn by diabetics, allowing them to manage their diet and medication more accurately.

Lenses that also contain arrays of tiny LEDs may allow this or other types of digital information to be displayed directly to the wearer through the lens. This kind of augmented reality has already taken off in cellphones, with countless software apps superimposing digital data onto images of our surroundings, effectively blending the physical and online worlds.

Making it work on a contact lens won't be easy, but the technology has begun to take shape. Last September, Sensimed, a Swiss spin-off from the Swiss Federal Institute of Technology in Lausanne, launched the very first commercial smart contact lens, designed to improve treatment for people with glaucoma.

The disease puts pressure on the optic nerve through fluid build-up, and can irreversibly damage vision if not properly treated. Highly sensitive platinum strain gauges embedded in Sensimed's Triggerfish lens record changes in the curvature of the cornea, which correspond directly to the pressure inside the eye, says CEO Jean-Marc Wisner. The lens transmits this information wirelessly at regular intervals to a portable recording device worn by the patient, he says.

Like an RFID tag or London's Oyster travel cards, the lens gets its power from a nearby loop antenna - in this case taped to the patient's face. The powered antenna transmits electricity to the contact lens, which is used to interrogate the sensors, process the signals and transmit the readings back.

Each disposable contact lens is designed to be worn just once for 24 hours, and the patient repeats the process once or twice a year. This allows researchers to look for peaks in eye pressure which vary from patient to patient during the course of a day. This information is then used to schedule the timings of medication.

"The timing of these drugs is important," Wisner says.

Parviz, however, has taken a different approach. His glucose sensor uses sets of electrodes to run tiny currents through the tear fluid and measures them to detect very small quantities of dissolved sugar. These electrodes, along with a computer chip that contains a radio frequency antenna, are fabricated on a flat substrate made of polyethylene terephthalate (PET), a transparent polymer commonly found in plastic bottles. This is then moulded into the shape of a contact lens to fit the eye.
Parviz plans to use a higher-powered antenna to get a better range, allowing patients to carry a single external device in their breast pocket or on their belt. Preliminary tests show that his sensors can accurately detect even very low glucose levels. Parvis is due to present his results later this month at the IEEE MEMS 2011 conference in Cancún, Mexico.

"There's still a lot more testing we have to do," says Parviz. In the meantime, his lab has made progress with contact lens displays. They have developed both red and blue miniature LEDs - leaving only green for full colour - and have separately built lenses with 3D optics that resemble the head-up visors used to view movies in 3D.

Parviz has yet to combine both the optics and the LEDs in the same contact lens, but he is confident that even images so close to the eye can be brought into focus. "You won't necessarily have to shift your focus to see the image generated by the contact lens," says Parviz. It will just appear in front of you, he says. The LEDs will be arranged in a grid pattern, and should not interfere with normal vision when the display is off.

For Sensimed, the circuitry is entirely around the edge of the lens (see photo). However, both have yet to address the fact that wearing these lenses might make you look like the robots in the Terminator movies. False irises could eventually solve this problem, says Parviz. "But that's not something at the top of our priority list," he says.

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Focus

Fri Jan 07 08:45:52 GMT 2011 by Eric Kvaalen

How can an LED sitting right on your eye's lens direct its light to a single spot on your retina?

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Focus

Tue Jan 11 16:33:17 GMT 2011 by Albert911emt

I don't believe it would need to. In the same way that the lenses in your eyes direct the light from your surroundings into your eyes and onto the retina, the same should be true for the displays generated by the contacts.

replyreport this comment

Focus

Thu Jan 13 08:13:39 GMT 2011 by Eric Kvaalen

But our natural lenses are only able to focus light onto the retina if the object we are looking at is several inches away (or even a couple feet away for some of us). The only way an apparatus sitting directly on our eye could do this would be if it shot a non-diverging beam of light into our eye. That would require some sort of three-dimensional apparatus, like a tiny LED held a small distance away
from the surface, and a powerful little lens, on the surface of our lens, focusing on that LED. Or a little laser aiming into our eye.

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Focus

Thu Jan 13 13:50:33 GMT 2011 by beany

Have you ever had a hair on your glasses while you've been wearing them? All you see is a very blurred, but easily distinguishable line. It's very out of focus, but you know its a line all the same. With a clever bit of optics and a very low power LED, its possible they could get the effect they want, though it isn't going to be easy. I for one am looking forward to seeing what comes from this technology

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Eye strain! Triggerfish will know (Image: Sensimed)

Augmented reality contact lenses
All this talk about augmented reality is all well and good, but *wandering around holding up a little rectangular gadget to see things through* is hardly an elegant science fictional solution, now is it?

As a fully paid-up cyberpunk, I want everything as tightly integrated to the meat as possible – so I want my AR operating no further from me than the surface of my eyeballs. Luckily I shouldn’t have too long to wait – at least *not if Babak Parviz of the University of Washington has the successes he hopes for with his augmented reality contact lens concept:*

Conventional contact lenses are polymers formed in specific shapes to correct faulty vision. To turn such a lens into a functional system, we integrate control circuits, communication circuits, and miniature antennas into the lens using custom-built optoelectronic components. Those components will eventually include hundreds of LEDs, which will form images in front of the eye, such as words, charts, and photographs. Much of the hardware is semitransparent so that wearers can navigate their surroundings without crashing into them or becoming disoriented. In all likelihood, a separate, portable device will relay displayable information to the lens’s control circuit, which will operate the optoelectronics in the lens.

These lenses don’t need to be very complex to be useful. Even a lens with a single pixel could aid people with impaired hearing or be incorporated as an indicator into computer games. With more colors and resolution, the repertoire could be expanded to include displaying text, translating speech into captions in real time, or offering visual cues from a navigation system. With basic image processing and Internet access, a contact-lens display could unlock whole new worlds of visual information, unfettered by the constraints of a physical display.

Parviz has a long old article there, and for those with a more technical bent it gives an insight into the way the contacts will actually work... though he’s canny enough not to put a solid date on the technology becoming available. [via New York Times; image by pasikary76]

**I wonder if he needs any test subjects?Inside These Lenses, a Digital Dimension**
EARBUDS can pipe audio directly from a portable player to the ear. But did you ever imagine that eyeglasses or contact lenses could deliver digital images directly from a smartphone to the retina?

An eyeglass from SBG Labs has a tiny projector in its frame. Holographics optics create an overlay image — for example, a map to the wearer’s destination.
Babak Parviz

A contact lens created by Babak A. Parviz and a team at the University of Washington in Seattle offers built-in electronics to create displays.

Several companies are developing prototypes for digital devices that look like stylish eyewear but may one day offer such capabilities to consumers. The glasses are called heads-up displays because the wearer can always look through them and see the real world — like the sidewalk just ahead — but can also see, on an overlay image, virtual information like an electronic map or an arrow showing the correct way to a destination. The glasses may also help the wearer remember the name of a long-lost friend she sees on the street.

SBG Labs, an optical technology company in Sunnyvale, Calif., is among the businesses that are developing the devices. The glasses are only slightly larger than many chic pairs of wraparounds, but instead of bearing rhinestones or designer initials, they hold a tiny projector and optics — tucked away in the side of the frame.

Such devices may have considerable appeal for consumers, so long as the glasses are attractive and lightweight, said Henry Fuchs, a professor of computer science at the University of North Carolina at Chapel Hill. Professor Fuchs is a pioneer in the creation of precursors to these glasses: large, head-mounted display systems — worn, for example, by soldiers who use them to see information like a map reflected on the visor of a helmet. These displays, though, are typically quite heavy to wear.

“People who work on head-mounted displays are hungering for something that people would be willing to wear for more than an hour,” he said, “something that would go in one’s eyeglasses and not be too much clunkier than regular eyeglasses.”

No price has been set for the SBG eyeglasses, which are still in the prototype stage, said Jonathan Waldern, the company’s founder and chief technology officer. SBG is concentrating on military and avionics applications, with consumer uses to follow.

The technology uses a process called holographic optics. Light-emitting laser diodes in the projector, stored in the side of the frame, shoot their highly concentrated beams forward to the eyeglass surface. There, computerized, transparent devices called holographic gratings diffract light in ways that ordinary optical components like prisms can’t, steering it to the user’s eyes.

Contact lenses are also being developed for mobile displays. Babak A. Parviz, an associate professor of electrical engineering, with his team at the University of Washington in Seattle, has created a biocompatible contact lens that has miniaturized electronics and optoelectronics integrated into the lens.

Dr. Parviz says he is moving a step at a time in testing the lenses. Rabbits have worn them for 20 minutes without ill effects, he said. “The display has not yet been turned on while the rabbits are wearing the lenses,” he said. “But we have turned on the lenses while holding them with tweezers, and they work well.”
The light-emitting diodes and other semiconductor components of the display are made separately, then moved to the lens, which is made of the same plastic used in beverage bottles. Then the entire device gets a biocompatible coating.

“We embed everything in polymers similar to those in standard contact lenses,” he said. “The electronics and photonics are inside the plastic, so users won’t come in contact with them.”

So far, the group has been able to light up and control a single pixel. But the team hopes to increase the number of pixels gradually, to make higher resolutions, he said. “We will increase the resolution, and add color eventually,” he said.

A group led by Desney S. Tan, a researcher at Microsoft Research in Redmond, Wash., is working with Dr. Parviz.

“Our role is to come up with some of the applications for the technology,” Dr. Tan said, applications that are part of a research field he called augmented reality: the combining of digital and physical worlds, in which virtual information is layered onto a person’s view of the real world.

In one possible application, the eyewear could serve as the wearer’s personal whisperer at conferences and cocktail parties. “What if every time I passed by a person, I had their name come up on the display?” Dr. Tan asked. “We could even add information on the last time I saw them and what we chatted about. Personal contact lens displays: The transparent OLED done one better

May 14, 2009 (2:39 pm) By: Rick Hodgin
If you’ve ever dreamed of having vision like Star Trek’s Georgi LaForge, seeing things beyond what’s actually there in the real world, even zooming in on the far off… well then you may need therapy, but apart from that there’s an emerging reality in a related field of science which may soon produce contact lens displays which augment the real-world experience.

Imagine an integrated, autonomous system designed to augment your visual experience with information relevant to your personal surroundings and immediate circumstances. Such a system would allow you to have access to information beyond your personal abilities, by providing reminders or cues that may not have otherwise occurred to you.
For example, the visual cues could be providing real-time GPS navigation which, rather than constantly looking over at your TomTom or Garmin, is naturally there with arrows, even being completely superimposed over what you’re naturally seeing, such as highlighting the exact path the car needs to take. Or, suppose you’re at a dinner party and you approach someone you met at a business meeting last year. You can’t quite remember his name, but in your heads up display — through some form of camera face recognition and access to a database — it pulls up not only his name, but his business line, family, and recent news which may be pertinent. You see all of this in real-time, but he just sees you. And when you say “Hi, Bill! How are Margie and the kids? And did that deal with XYZ Corp ever go through?” He’ll be impressed beyond words.

The truth is he probably won’t be, because when these devices are ready for such an application it’s probable he’ll also have one. And then I suppose it will come down to the geek level of how comprehensive each other’s database is: “Hi, William H. Tucker, III. How are Margaret Eleanor and your two kids, Christian Joseph, 11 and Amy Elizabeth, 8? And did that refinancing deal with XYZ Corp last October ever go through — I believe you were speaking with Danny Thompson?” To which he replies, “You know, Rick C. Hodgins, I’ve been following your articles on Geek.com in recent weeks … what’s up with all these sidelong allegories?” Okay, point taken.

The Eye

At the University of Washington (UW), and several other research centers around the world right now, the technology exists to create limited visual inputs which relate to tiny light sources embedded within the contact lens. While these were not physically enabled in the device linked below (meaning they did not illuminate due to no external power source hookup), they were physically present on the contact lens. Researchers believe any light presented by the lens at this stage would be interpreted by the eyes as being present and subsequently affecting the vision, but it would not be in focus or in any way usable.

In short, the technology necessary to create images or “data portals” as described above are many years away. And in fact, the technology necessary to make this kind of image appear is also quite distant.
Looking through a completed lens, you would see what the display is generating superimposed on the world outside. This is a very small step toward that goal, but I think it’s extremely promising. People may find all sorts of applications for it that we have not thought about. Our goal is to demonstrate the basic technology and make sure it works and that it’s safe.

In 2008, he was awarded Time Magazine’s Best Invention of the Year award for this device, which most believe shows amazing promise as the field of nanotechnology continues to grow and research into these technologies increases. When tiny, flexible on-lens solar cells are enabled to draw power from the light in the room, or when some tiny power supply can be created which uses minute reservoirs of fluid squeezed past nano-turbine generators through the muscle-based natural eye blinking motion, then the technology will be approachable for real-world applications.

Until then, research like what is taking place at NASA and their JORDY (Joint Optical Reflective Display) device, a real-world device which does augment vision notably for those afflicted with diabetes, macular degeneration, glaucoma, etc., will be usable. This device allows for real-world zooming, adjustment of contrast, brightness, colors, etc., to compensate for the way the eye is seeing images.

As of the last report Dr. Pariz has published on the technology (from January, 2008), he was at the point where he’d tested the lens only on rabbits, and only for 20 minutes (see purple image above). The rabbits showed no ill effects from “wearing” the device, and his research is continuing.

His research was funded by the National Science Foundation, and a Technology Gap Innovation Fund from the University of Washington in Seattle.

See the original article published on Eurekalert in January, 2008.
Rick’s Opinion

When I met and spent the morning with Dr. Jerry Bautista on their prototype Terascale project (back in late 2007), one of the potential uses he discussed for Terascale was this very application. The ability to have enough computing power to present to the user via some kind of display, an overlay of the real world. He imagined the device mathematically compensating for the distance between the device and the user’s eyes, correct the display so that it exactly overlays the real-world.

One particular item we discussed was GPS assisted driving, as well as tourist-like information. We envisioned holding up a sheet-of-glass-like transparent display, which then allows us to see buildings directly through it. But then overlaid on each building would be histories, businesses inside, hours of operation, distance to get there, last time we were there, etc. Terascale would provide enough parallel compute abilities to do as many database lookups for information relating to every aspect within our field of vision that the data could be displayed in real-time.

Imagine driving by a movie theater in your car. You hold up the device so you can see the movie theater through the glass and your eye, and it automatically shows you shows playing, show times, cost, and with real-time feedback, how crowded the theater is, etc.

These kinds of massively parallel compute-enabled human augmentation devices are coming. The form they take will not really be the crucial issue at first, but rather getting there. With today’s power requirements, it would literally take something plugged into the wall to provide the computing power necessary to handle it all. In addition, the databases and real-time wireless Internet access are simply beyond our abilities outside of the lab today. However, tomorrow is another story, and these are all just engineering hurdles to be overcome.

Do you think when man invented the first car he envisioned the Ferrari? At some point someone took the idea and extended it and the Ferrari came into existence. The same is going to happen with The Eye

The past is the future for hi-tech
Your eyes could become a target for hi-tech hackers.

We still don't think enough about securing our technology, says regular commentator Bill Thompson

As December comes to an end journalists and pundits around the world have been telling us which devices or technologies they think are the most important from the last year.

Here on the BBC tech site Rory Cellan-Jones chooses cloud computing while Jonathan Fildes opts for smartphone applications and Maggie Shiels reveals her love for her Blackberry, to which she is clearly addicted.

Picking one innovation as the most important or as representative of a year is notoriously difficult, but it is at least retrospective.

The iTunes Application Store was one of the year's biggest successes, whatever one might think of Apple's arbitrary approvals process or the constraints placed on application authors, and Google really did launch Wave, albeit as an early, buggy alpha release.

"...the sort of systems thinking that would make data security an essential part of the design process
Looking forward is much trickier. When it comes
to recent innovations it is simply too early to
decide their impact, so there is no way we can tell
whether Wave really will bring about a revolution
in collaborative working or fade away into
technology history.

The rate of technological change is so fast that extrapolation simply cannot be useful guide, with new
products and services appearing all the time.

Nobody can tell how the ebook market will adapt to the imminent release of Apple's tablet computer
because we don't yet know what the tablet will look, feel or work like.

That doesn't stop us trying, of course, even if we get it painfully wrong.

I recall predicting the imminent death of the analogue modem several years before they even began to
decline in popularity, while my final column of 2005 includes an admission that I'd failed to appreciate
the disruptive impact of wireless technology in previous years.

On the up side, I did use the same column to point out the danger that the music industry would never
learn to trust their customers but try "to exert even more control, and perhaps using their lobb ying
powers to change laws to make their systems unavoidable".

**Looking ahead**

However, as we enter the last year of the first decade of the 21st century I am willing to stick my neck
out and make a prediction about a technology that is still in the lab and is at least 10 years from being
commercially available.

I am confident that at some point around 2020 we will all be distracted by early reports that the latest
display technology using smart contact lenses that draw images directly onto the retina using low-
powered micro-lasers are being hacked into by unscrupulous criminals.

They will be replacing paid-for adverts with ones for their own illicit services while using the
augmented reality data feeds that the lenses offer to steal personal data and infiltrate company
networks.

*is still rare enough to be remarkable.*

Bill Thompson
At that point the manufacturers of the lenses will scramble to add some high-end security to the data transfer protocol used to link their lenses to the personal data networks we have all adopted by then, but doing so will break lots of applications and services and never be widely adopted.

People will prefer to live with the risk of seeing the odd pornographic image to having to reconfigure a product that was sold as being "as easy as seeing", and the criminal gangs will continue to harvest personal data and sell illicit advertising.

Digital contact lenses are one the technologies that have recently become possible thanks to some breakthrough work in the research labs.

They are under development at the University of Washington, where Babak Parvis has a prototype with a single red LED, powered by radio frequency transmissions like the passive RFID chips in Oyster cards.

Eventually he believes we will have lenses with built-in control circuits, display circuits and miniature antennae that project images directly onto the retina. Although the engineering hurdles to be overcome are enormous this one feels to me like something we will see in the mass market within a decade.

But I have a horrible feeling that in all the excitement about getting the things to actually work the developers will not bother to build encryption into the data transfer protocols, because doing so will delay bringing them to market or add too much to the cost.

**Lessons to learn**

The past may not always be a good guide to the technological future, but sometimes it is, and the development of medical implants offers a salutary lesson here.

Pacemakers and other devices have been implanted in people for many years, and more and more of them have some form of wireless monitoring and control.

Over the years we've looked at many on Digital Planet, the World Service radio programme I appear on as studio expert because they are an important medical advance, not least because they reduce the need for repeat surgery.
And in March 2008 researchers at the University of Massachusetts, Amherst demonstrated that you could snoop on the radio signal coming from a combination pacemaker/defibrillator and reprogram it to deliver a potentially lethal electric shock to a patient.

Their experiment required several students and some expensive equipment to monitor and decode the signals from a Medtronic Maximo pacemaker, but it prompted significant concern within the medical profession because of the danger it exposed.

Up to that point the manufacturers had been worried about possible interference with the implants from external radio sources like metal scanners or store alarms, and the potential for hacking seems not to have occurred to them.

I fear that we will see the same pattern repeat itself again and again, because the sort of systems thinking that would make data security an essential part of the design process is still rare enough to be remarkable.

The first generation of analogue mobile phones sent conversations in the clear, and it was only when they went digital that some encryption was built in, and this sort of short-sighted thinking still seems prevalent.

Your Cyborg Eye Will Talk to You

- Sign In to E-Mail
- Print

By DANA OSHIRO of ReadWriteWeb
Published: September 1, 2009

Just as many of us are getting used to augmented reality applications for cellphones and digital cameras, Babak Amir Parviz and his University of Washington students are taking it one step further. The group is working on a human machine interface where LEDs are embedded into contact lenses in order to display information to the wearer. You heard right, in a few years your cyborg eye will talk to you. In an article with the IEEE Spectrum, Parviz relays the challenges of custom-building semi-transparent circuitry into a polymer lens roughly 1.2 millimeters in diameter.

Skip to next paragraph

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Says Parviz, "We're starting with a simple product, a contact lens with a single light source, and we aim to work up to more sophisticated lenses that can superimpose computer-generated high-resolution color graphics on a user's real field of vision."

For now, Parviz mentions that single pixel visual cues for gamers and the hearing impaired are already quite possible with the lens prototypes. The group has also experimented with non-invasive biomonitoring including checking glucose levels for diabetics.

Some of the obvious challenges of building an augmented reality contact lens include:
1. The Need for Custom Parts: Regular circuitry and LEDs are incompatible with regular contact lenses. Every piece of this project must be fabricated from scratch.

2. Physical Constraints: The group must attempt to fit transistors, radio chips, antennas, diffusion resistors, LEDs and photodetectors onto a miniscule polymer disc. Additionally, the team is required to control lens position and light intensity relative to the pupil. And finally, because the lens is so close to the corneal surface, the group must project images away from the cornea using either micro-lenses or lasers.
3. User Safety: In addition to protecting the eye against chemicals, heat and toxins, the lens components must be semi-transparent in order for the wearer to view their surroundings.

"We already see a future in which the humble contact lens becomes a real platform, like the iPhone is today, with lots of developers contributing their ideas and inventions. As far as we're concerned, the possibilities extend as far as the eye can see." And you thought the iPhone SDK was a tough nut to crack.