Introduction to *Augmented Reality* for Teaching and Learning

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Isadora Mok-Kulakova

November 29, 2018

An important reminder

Please sign in!

*If your name is not on the sign-in sheet, please add it together with your email address – you will be registered after the workshop. *Also, use the sign-in sheet to correct your name or email.*

This badge is part of the Postdoctoral Scholar and Graduate Student Certificates in University Teaching and Learning program.

http://www.ucalgary.ca/taylorinstitute/certificates-university-teaching-and-learning

Today's Outcome

- ***Explore*** what Augmented Reality (AR) technology is, why and how to use it in your teaching and learning.
- ***Create*** your own Augmented Reality resources.

Have Fun!

Augmented Reality ?

Google Translate supports over **100 languages** at various levels and as of **May 2017**, serves over **500 million people daily**.

Google Neural Machine Translation (GNMT) is a neural machine translation (NMT) system developed by Google and introduced in November 2016

Augmented Reality (AR)

science-fiction **concept** to a science-based **reality**.

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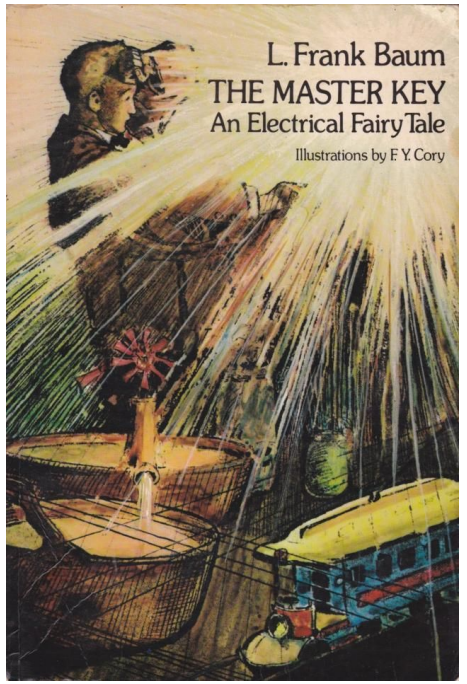
"It consists of this **pair of spectacles**. While you wear them **every one** you meet will be **marked** upon the forehead with a letter **indicating his or her character**. The good will bear the letter 'G,' the evil the letter 'E.' The wise will be marked with a 'W' and the foolish with an 'F.' The kind will show a 'K' upon their foreheads and the cruel a letter 'C. Thus you may determine by a single look the true natures of all those you encounter."



This character marker has been viewed retrospectively as an early foreshadowing of features analogous to those obtainable in augmented reality devices.

Lyman Frank Baum (May 15, 1856 – May 6, 1919) was an American author chiefly famous for his children's books, particularly *The Wonderful Wizard of Oz* and its sequels.

Want to know more about AR History?

Augmented Reality (AR)

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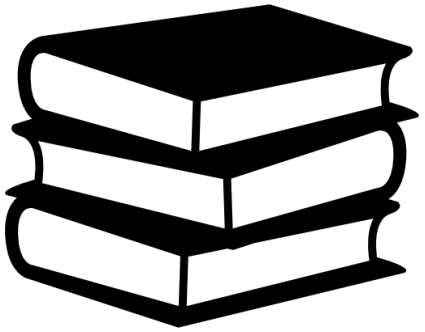
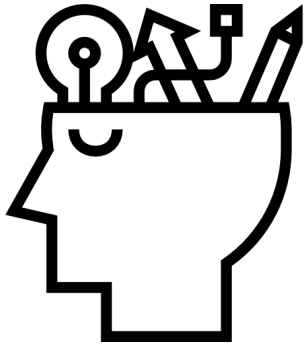
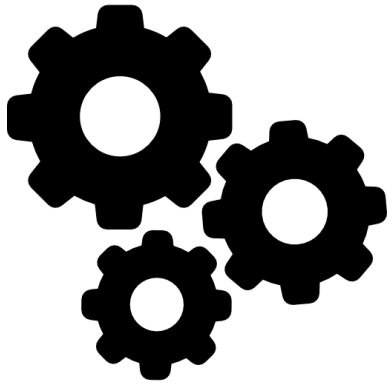
Definition



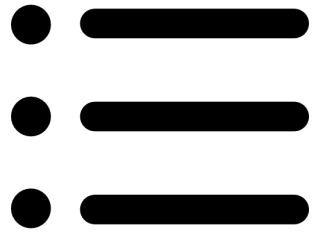
Making Sense



How it Works



Types



Click on the pictures to access more information, then "Go Back"

Augmented Reality & Education

back to outcomes

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- Interactive learning
- Portable and less expensive materials: cellphones, tablets

Why?

- Foster intellectual curiosity
- Enrich ways of telling a story
- Visit different times: past/present/future, scales: micro & macro universes
- Increase sensory experiences

TOOLBOX

SCIENCE GOES VIRTUAL

Virtual- and augmented-reality tools allow researchers to view and share data as never before. But so far, they remain largely the tools of early adopters.

BY DAVID MATTHEWS

As I put on a virtual-reality (VR) headset, the outside world disappears. A cell fills my visual field, and as I crane my neck, I can see it from several angles. I stick my head inside to explore its internal structure. Using hand controllers, I dissect the cell layer by layer, excavating with a flick of the wrist to uncover tiny, specialized structures buried beneath the surface.

Looking at a cell in VR is "as close as you can get to touching" such a minuscule structure, says Sebastian Konrad, product manager for VR at Arivis, a life-sciences software company in Munich, Germany, that developed this particular VR visualization tool, called InVieweR, and who helped to arrange my demonstration of it.

VR isn't new, but interest in the technology has boomed since 2016, when gamers and a handful of scientists introduced several high-quality, relatively inexpensive commercial headsets to the public. A similar surge has emerged in augmented reality (AR), a related technology that uses a see-through visor or smartphone screen to layer objects on top of real surroundings.

Some scientists see VR and AR as more intuitive to use than conventional flat screens for viewing complex 3D structures. Others have sought cheap, smartphone-based headsets, which use a smartphone screen as the goggles, to increase public understanding of their work. Their numbers are relatively small: VR and AR remain niche tools for scientific research. Yet some researchers say that the ▸

Activity Plan for Today

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Explore

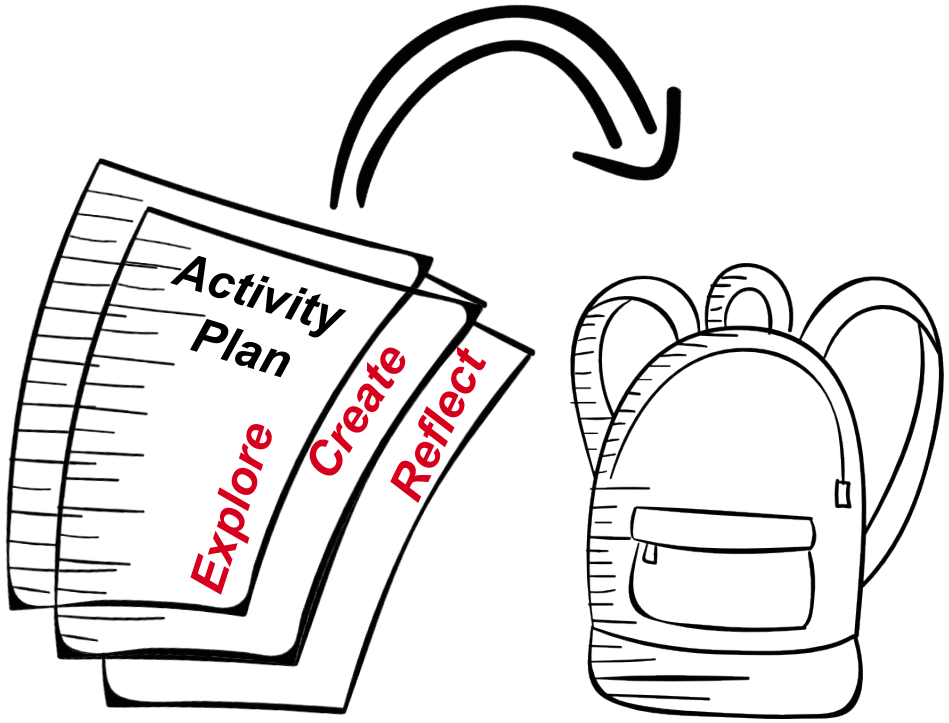
Augmented Reality Applications in Education.

Create

Augmented Reality resources using a cellphone App and web-based tools.

Reflect

How to use Augmented Reality in your classroom.



Working Tools

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Explore

AUGMENT

Let’s experience some examples!

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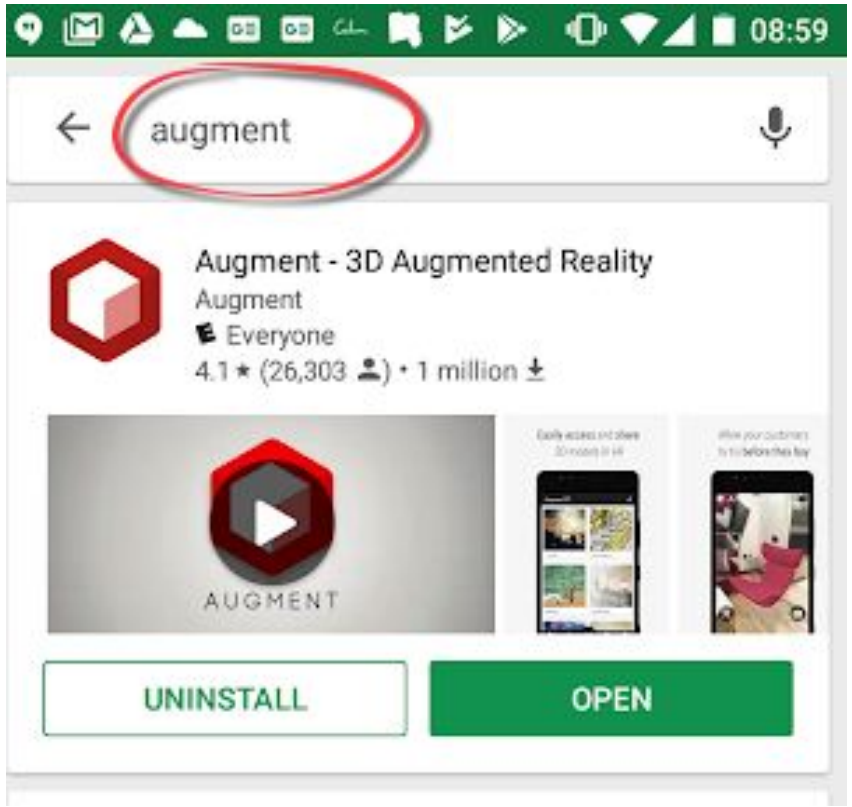
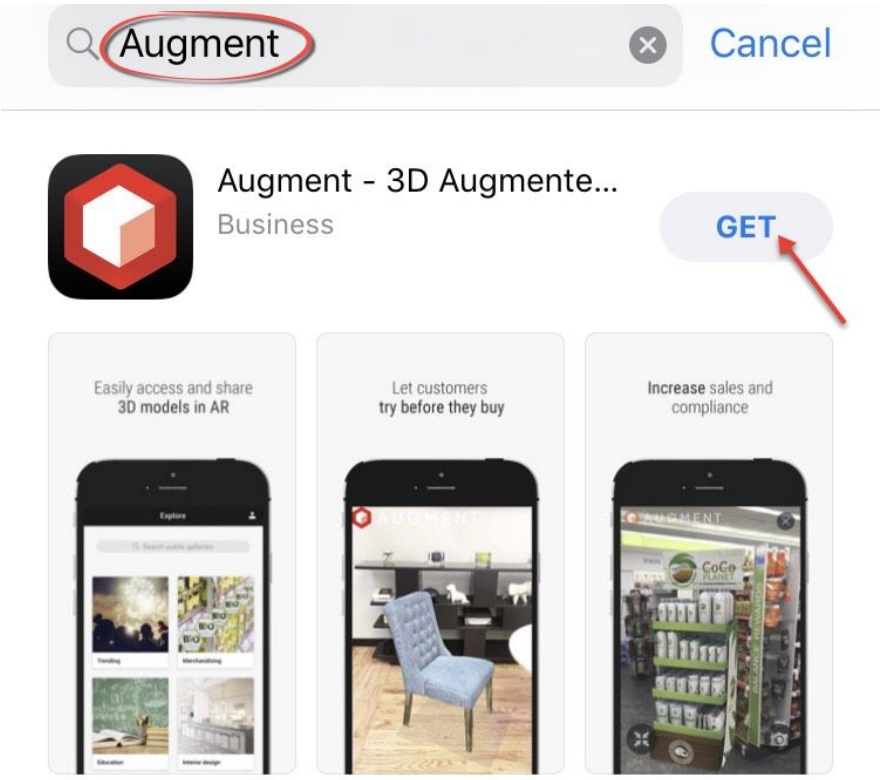
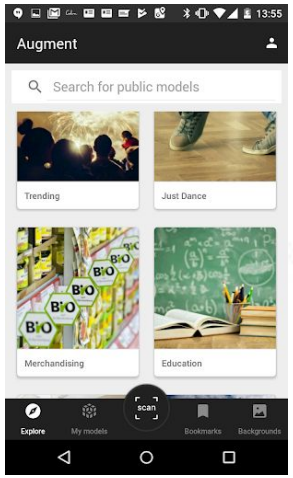
GET IT ON Google Play

Download on the App Store

Explore







AUGMENT

Augment Apps

View your 3D models in AR on your smartphone or tablet for IOS & Android

Augment Desktop

Preview & configure your 3D models before viewing them in AR

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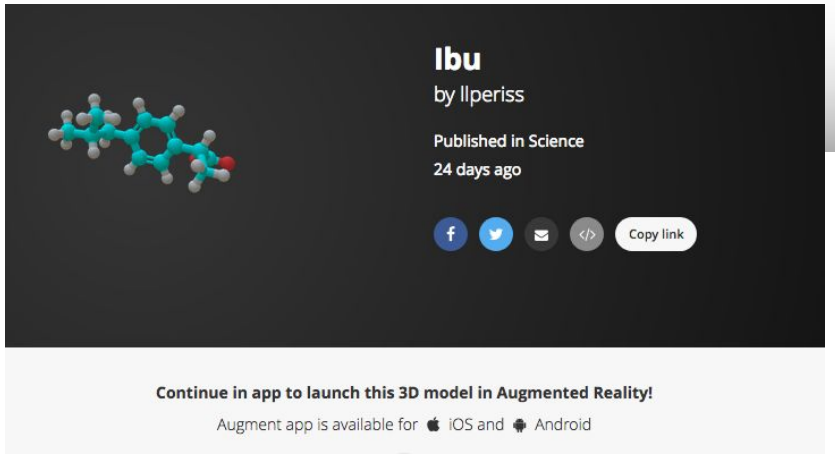
[Install Software]

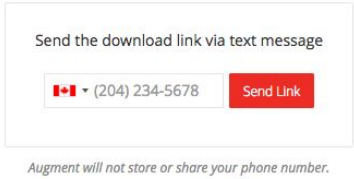
https://bbp.epfl.ch/nexus/cell-atlas/



Augment Manager

Manage & share your 3D

http://www.augment.com/help/3d-file-format-guidelines/



1-Open the App

2- Select a Model

3-Learn, Discover, Enjoy, Capture

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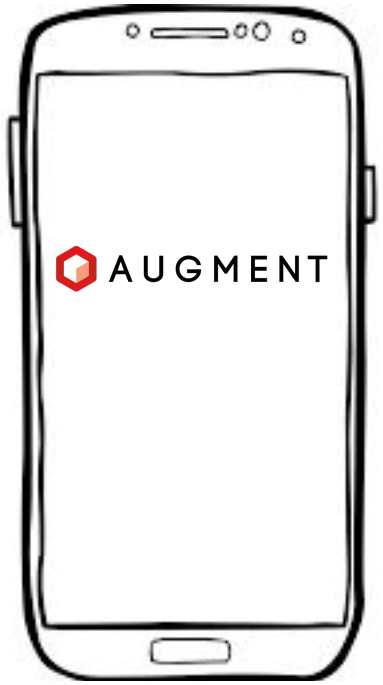

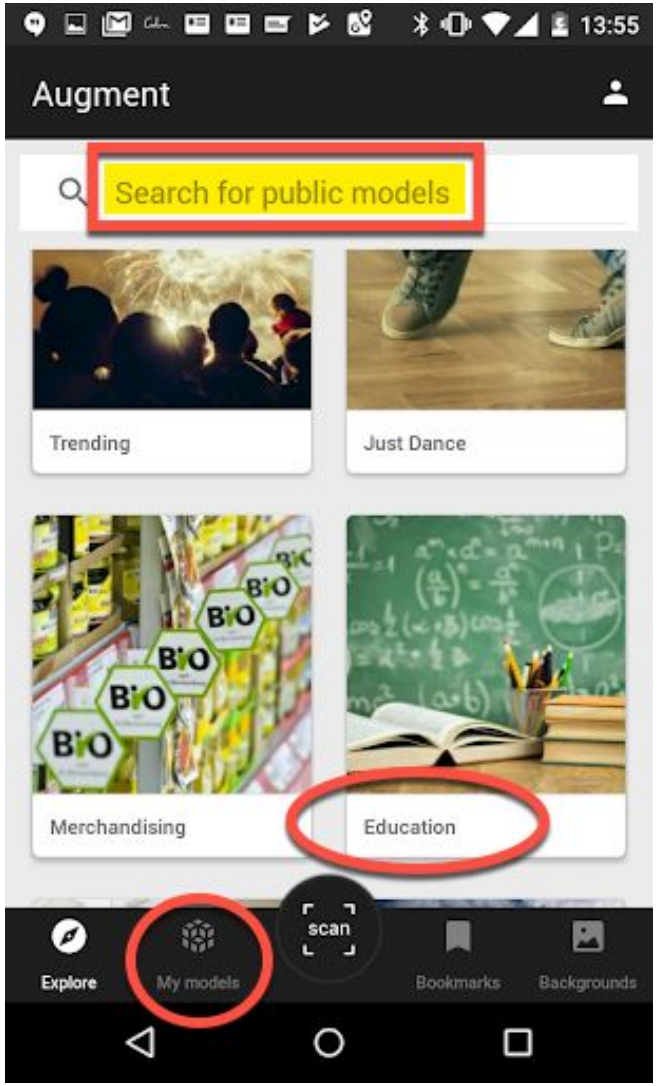

2- Scan the QR code

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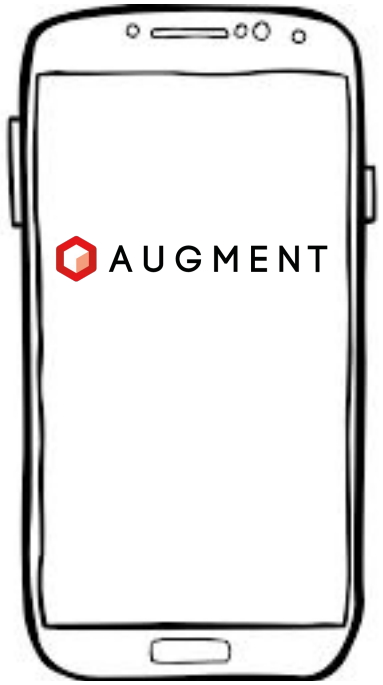
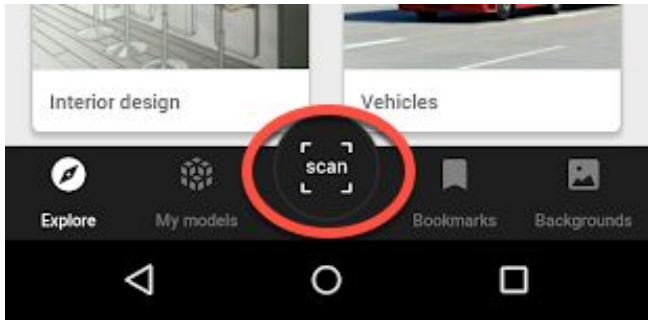
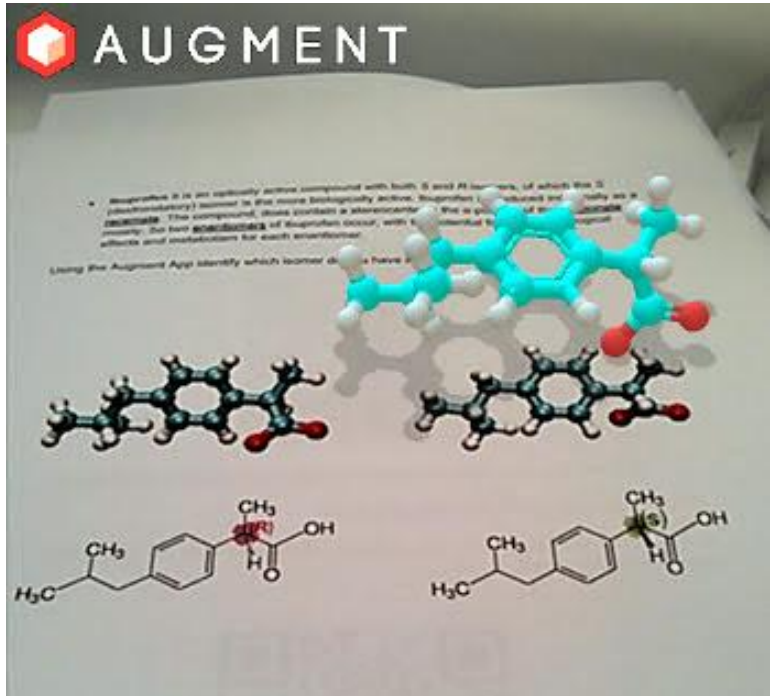




3-Learn, Discover, Enjoy



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1-Open the App

2- Scan the image

3-Learn, Discover, Enjoy

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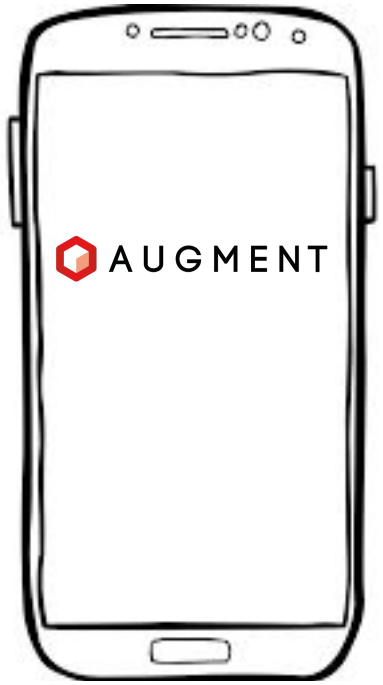

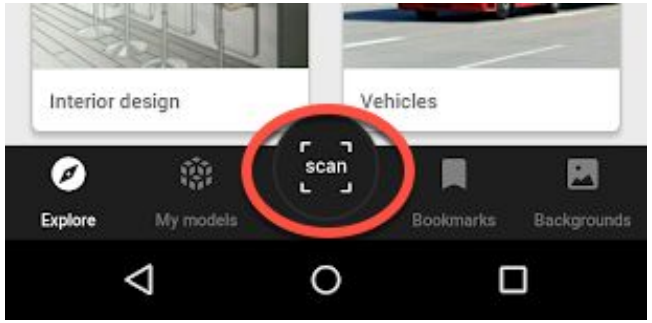

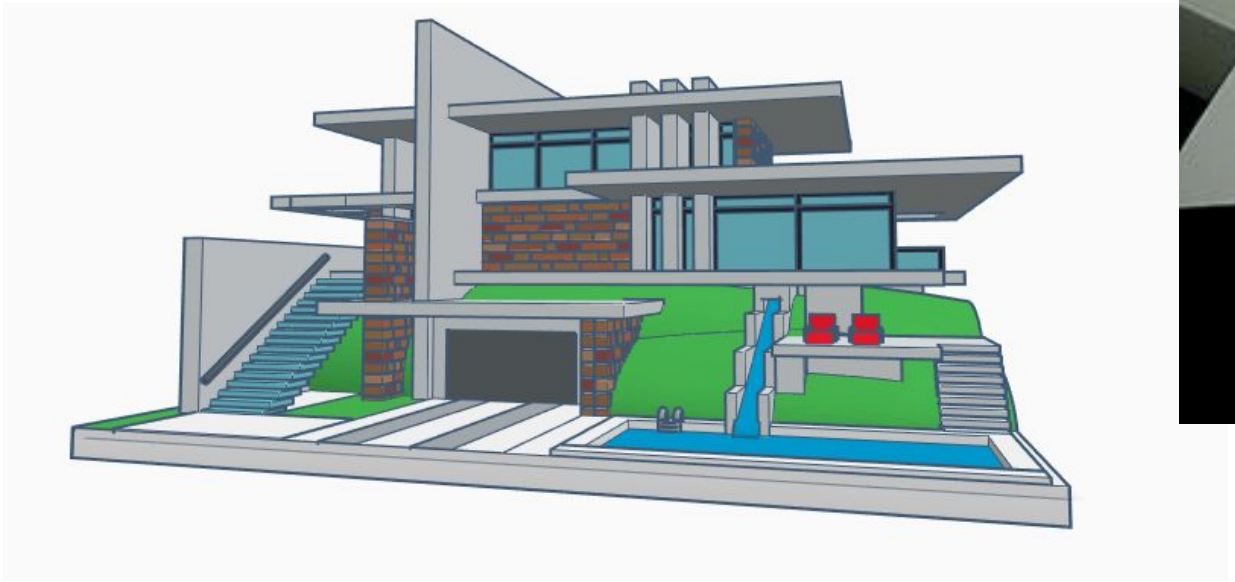

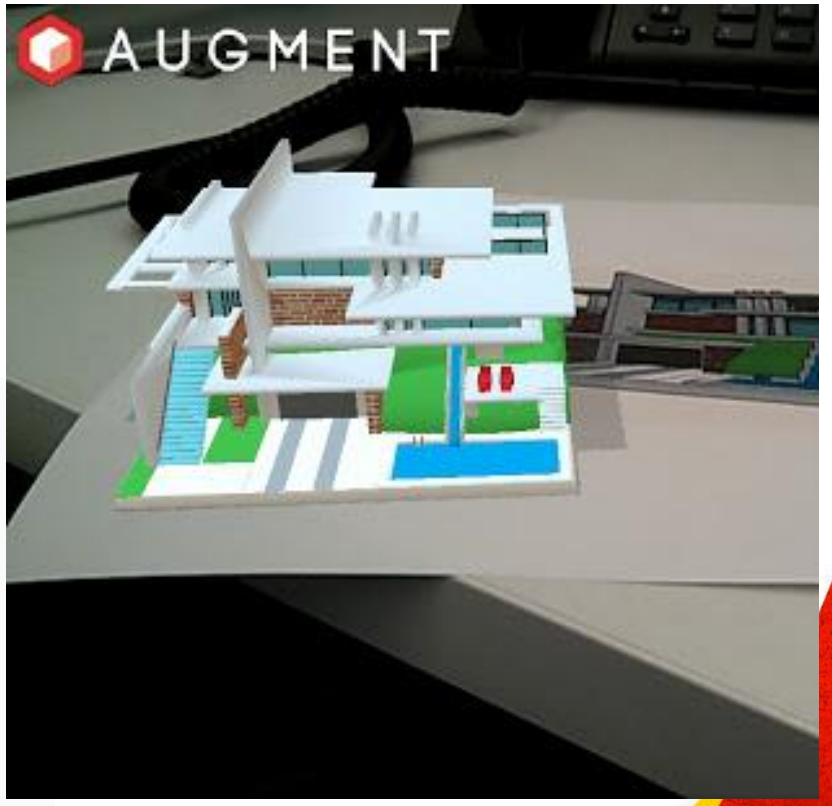

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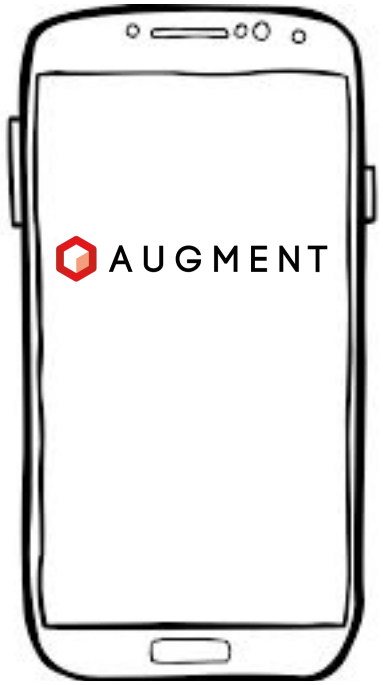
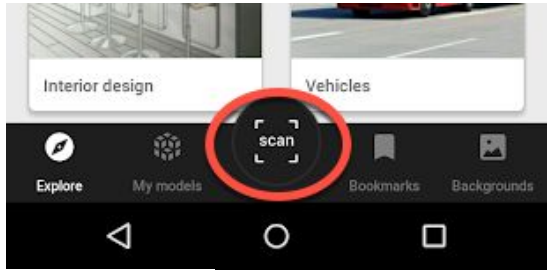


2- Scan the paper



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PNAS PNAS PNAS

Structure and mechanotransmission mechanism of the MacB ABC transporter superfamily

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Edited by Thomas J. Silhavy, Princeton University, Princeton, NJ, and approved October 10, 2017 (received for review July 10, 2017)

MacB is an ABC transporter that collaborates with the MacA adaptor protein and TolC exit duct to drive efflux of antibiotics and enterotoxin STII out of the bacterial cell. Here we present the structure of ATP-bound MacB and reveal precise molecular details of its mechanism. The MacB transmembrane domain lacks a central cavity through which substrates could be passed, but instead conveys conformational changes from one side of the membrane to the other, a process we term mechanotransmission. Comparison of ATP-bound and nucleotide-free states reveals how reversible dimerization of the nucleotide binding domains drives opening and closing of the MacB periplasmic domains via concerted movements of the second transmembrane segment and major coupling helix. We propose that the assembled tripartite pump acts as a molecular bellows to propel substrates through the TolC exit duct, driven by MacB mechanotransmission. Homologs of MacB that do not form tripartite pumps, but share structural features underpinning mechanotransmission, include the LolCDE lipoprotein trafficking complex and FtsEX cell division signaling protein. The MacB architecture serves as the blueprint for understanding the structure and mechanism of an entire ABC transporter superfamily and the many diverse functions it supports.

ABC transporter | X-ray crystallography | tripartite efflux pump

Tripartite efflux pumps (TEPs) span the inner and outer membranes of Gram-negative bacteria to mediate export of protein toxins, antibiotics, and virulence factors (1). In *Escherichia coli*, the inner membrane ABC transporter MacB (2), adaptor protein MacA, and TolC exit duct (3) form a TEP that confers resistance to macrolide antibiotics (2, 4, 5) and exports heat-stable enterotoxin STII (6, 7). ABC transporters are composed of nucleotide binding domains (NBDs) required for ATP hydrolysis and transmembrane domains that typically facilitate passage of the substrate through the membrane in which they reside, using an alternating access or toppling mechanism (8, 9). MacB is unlikely to use such mechanisms for enterotoxin transport, as it resides in the inner membrane and transports enterotoxin STII from the periplasm to the extracellular space (6).

MacB contains four transmembrane helices, an N-terminal NBD, and an extensive periplasmic domain located between TM1 and TM2 (10, 11). MacB homologs operate either within or independent of TEPs to perform a multitude of roles (12, 13). TEP-independent MacB homologs include key proteins involved in lipoprotein trafficking (LolCDE) and cell division (FtsEX) (12). LolCDE extracts lipoproteins from the inner membrane to a periplasmic chaperone (14), and FtsEX is thought to alter conformation of its periplasmic domain to recruit and activate periplasmic peptidoglycan hydrolases during bacterial cell division (15). Similar to MacB, LolCDE and FtsEX do not transport substrates across the inner membrane, but instead use cytoplasmic ATP hydrolysis to perform work in the periplasm.

Here, we present the crystal structure of ATP-bound MacB at 3.35 Å that, in combination with a nucleotide-free form derived from a cryoEM structure of the MacAB-TolC assembly (11), reveals a mechanotransmission mechanism. We demonstrate that MacB is representative of a wider family of ABC transporters that use the same architecture and mechanism to perform diverse biological functions.

Results

The Structure of MacB Defines the Type VII ABC Transporter Fold. We determined structures of ATP-bound MacB, using X-ray crystallography. After screening multiple MacB homologs, crystals of *Aggregatibacter actinomycetemcomitans* (hereafter *Aa*) MacB were obtained in two space groups, $P6_522$ and $P2_1$, and their structures solved at 3.90 and 3.35 Å resolution, respectively. Structures of the *E. coli* MacB periplasmic domain (1.95 Å) and cytoplasmic NBD (2.40 Å) were also determined. Structure determination for full-length *Aa*MacB was achieved using a combination of molecular replacement with the individual domains and selenomethionine-based anomalous scattering approaches. X-ray data and refinement statistics are given in *SI Appendix*, Tables S1 and S2, and representative electron density for the full-length MacB structure is shown in Movie S1.

The structure of *Aa*MacB is shown in Fig. 1*A*, colored consistently with its linear domain arrangement (Fig. 1*B*) and transmembrane topology (Fig. 1*C*). Each MacB monomer within the dimer contains four transmembrane helices (TM1–TM4, blue), an N-terminal nucleotide-binding domain (NBD, red), and a 198-residue periplasmic domain (purple) located between TM1 and TM2. The periplasmic domain is itself made up of two subdomains; the Sabre (Small alpha/beta rich extracytoplasmic) subdomain is composed of a single contiguous region of the MacB polypeptide (residues 347–465), and the Porter subdomain is formed from two β-α-β motifs (306–346 and 466–503) located on either side of the

Significance

Bacterial ABC transporters typically mediate transport of substrates across the cytoplasmic membrane, using either alternating access or toppling-based mechanisms. The noncanonical ABC transporter MacB does not behave in this manner, but instead couples cytoplasmic ATP hydrolysis with periplasmic conformational changes that drive substrates from the periplasm to the extracellular space via the TolC exit duct. Here we describe the mechanotransmission mechanism of MacB in molecular detail by comparing ATP-bound and nucleotide-free structures. We further show that MacB shares its structural architecture with an entire superfamily of ABC transporters responsible for fundamental bacterial processes, including cell division and outer membrane biogenesis, suggesting a common mode of operation, and raise the possibility of targeting such proteins for the development of new antibiotics.

Author contributions: A.C., N.P.G., E.K., and V.K. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

Data deposition: The atomic coordinates and structure factors have been deposited in the Protein Data Bank, www.wwpdb.org (PDB ID codes 5LIL, 5LJ6, 5LJ7, 5LJ8, 5LJ9, 5LJA, and 5NAA).

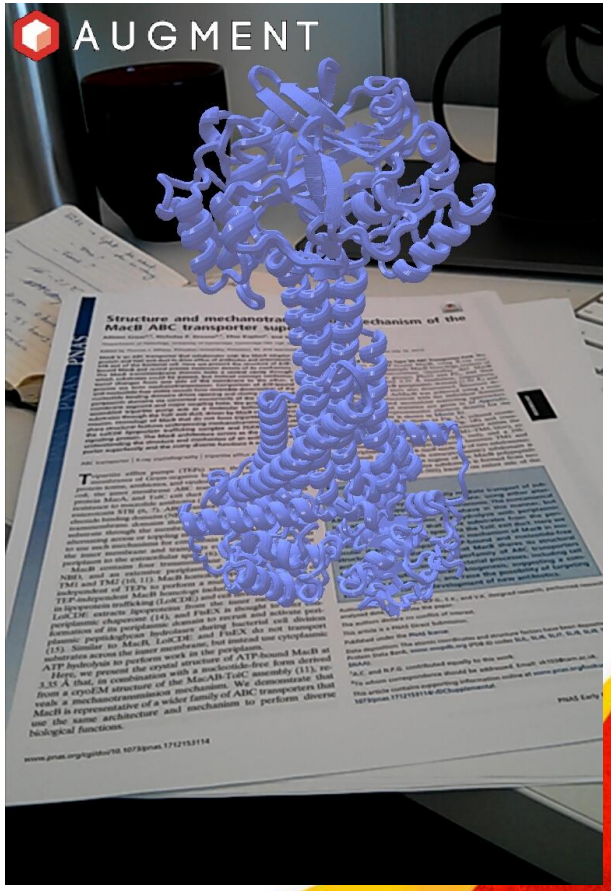
[1]A.C. and N.P.G. contributed equally to this work.

[2]To whom correspondence should be addressed. Email: vk103@cam.ac.uk.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1712153114/-/DCSupplemental.

MICROBIOLOGY

3-Experience 3D in your hand



Instructions:

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Explore

- Choose a subject area

AUGMENT

- Engage in the activities using the Augment App and think about how Augmented Reality (AR) can be used to enhance your Teaching and Learning.

- Where applicable, use the available physical models and objects and think about how they compare to the AR tool.

- Use the focus questions at each station to guide your reflection.

Working Tools

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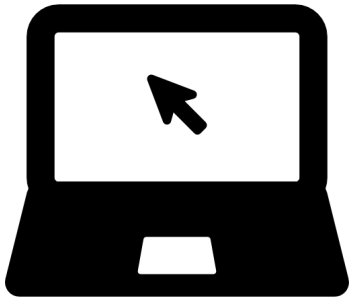
Create



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AUGMENT

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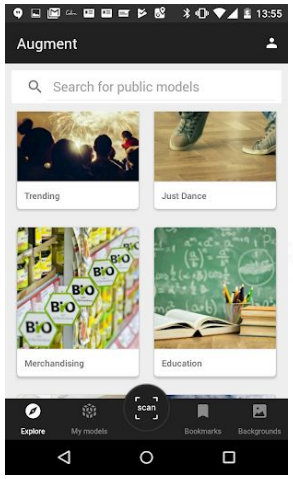
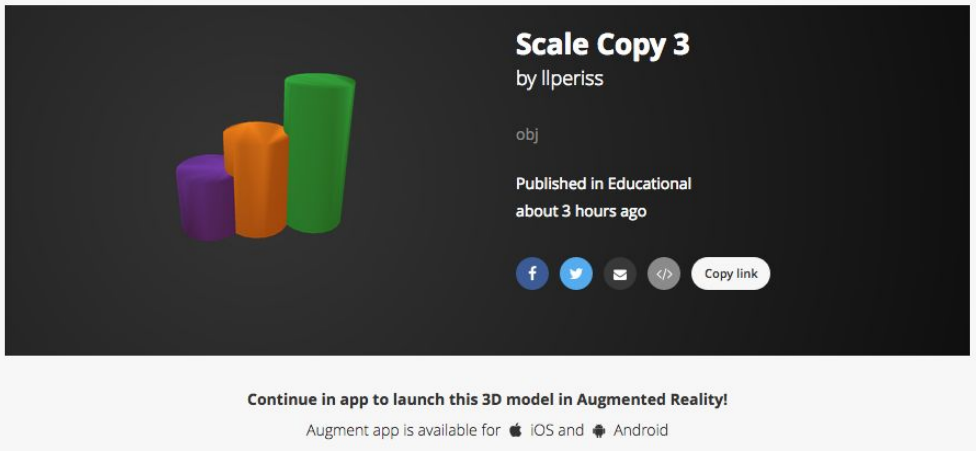


Augment Apps

View your 3D models in AR on your smartphone or tablet for IOS & Android

Augment Desktop

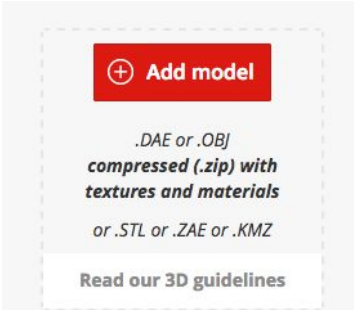
Preview & configure your 3D models before viewing them in AR

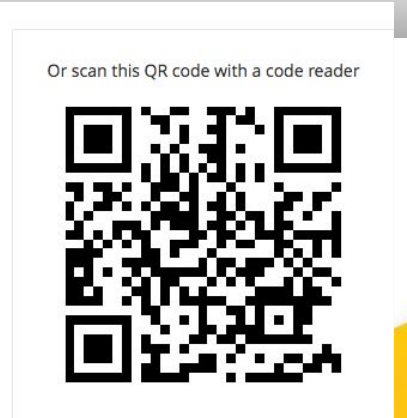


Augment Manager

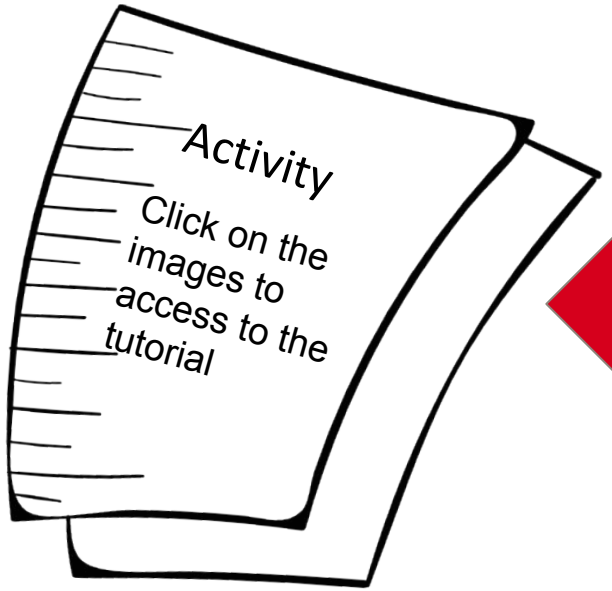
Manage & share your 3D

http://www.augment.com/help/3d-file-format-guidelines/





Create your Own Resource



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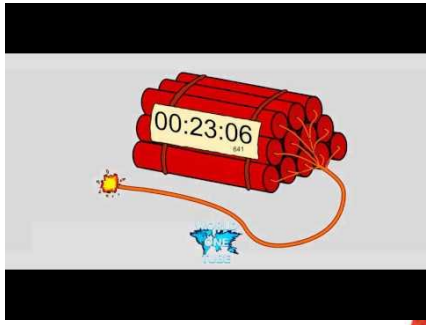
Create

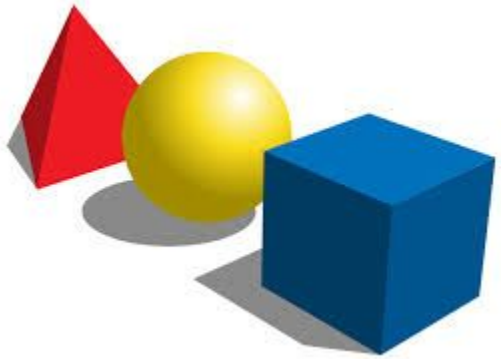


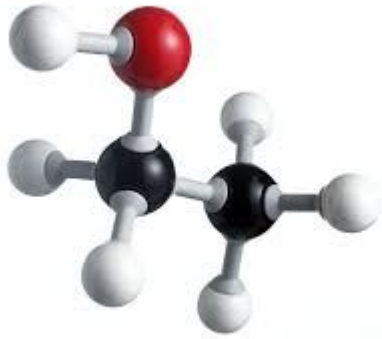
1- *Create* 3D Object

2- Upload file object

3- Share your creation

4- Play & Learn with AR!





How would you use AR in your own classroom?

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Reflect

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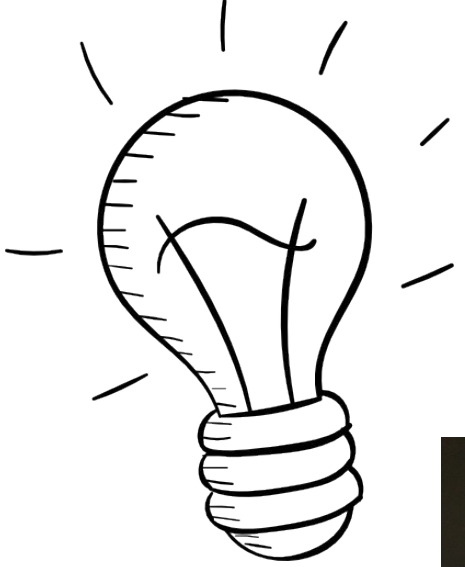
"...That's when I discovered, at least in this very simple operation of counting, the great difference of what goes on in a head when people think they are doing the same thing…"

Richard Feynman, BBC TV Series "Fun to imagine" (1983)

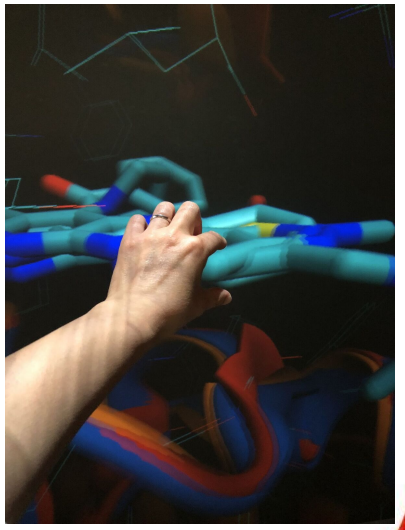
Have an Idea and need help?



- Taylor Institute for Teaching and Learning:
  https://taylorinstitute.ucalgary.ca/
  laura.perissinotti@ucalgary.ca

- LabNext Makerspace at TFDL:
  https://library.ucalgary.ca/labnext

- CCIT Collaboration Centre:
  http://www.collaborationcentre.ca/



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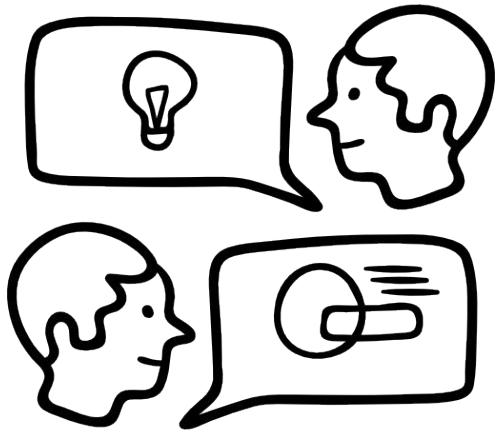
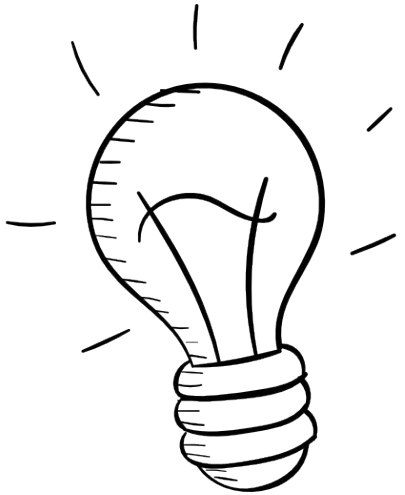
Experiment



Share



be *Creative*

Some of the Graphics were designed by Freepik from Flaticon

Augmented Reality (AR)

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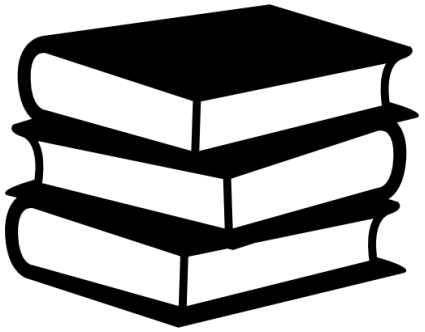
Definition



Technology that ***superimposes a computer-generated image*** on a ***user's view*** of the real world, thus providing an ***enhanced version of reality*** by adding information: graphics, sounds, and touch feedback.

Augmented Reality (AR)

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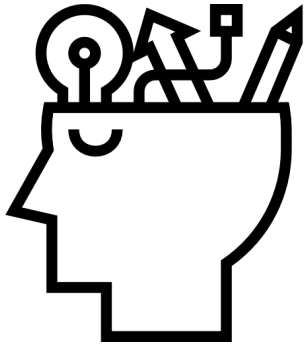
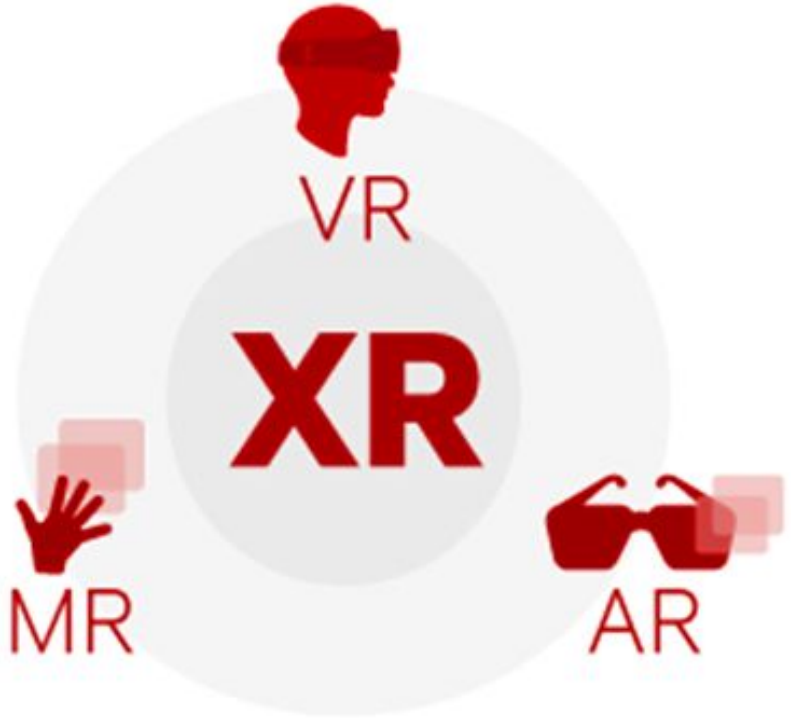
Making Sense



- *Augmented* is ***augment → to add or enhance something***.
- Provides cognitive support for difficult tasks



Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1994). Augmented reality: A class of displays on the reality–virtuality continuum. In Proceedings of Telemanipulator and Telepresence Technologies (pp. 282–292). Boston, MA.

Augmented Reality (AR)

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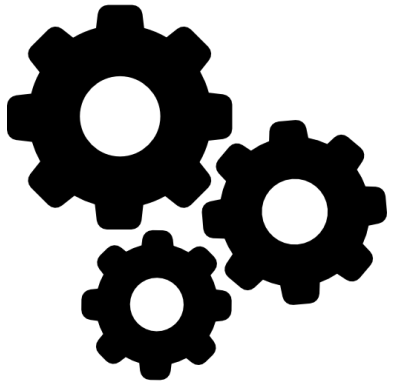
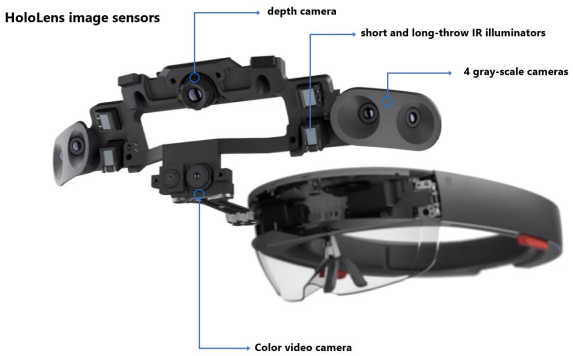
- Overlaying projected images on top of a pair of see-through goggles or glasses, smartphones cameras.
- Augmented Reality devices are often self-contained → do not need a cable or desktop computer to function

How it Works





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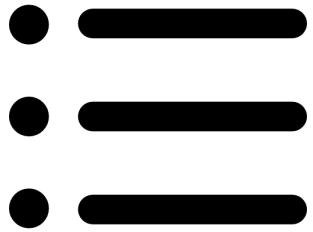
Types



- Marker/Image Based AR ⟶ Camera+Visual marker
- Placement ⟶ places 3D objects/ projections into the environment.
- Location Based AR ⟶ uses a GPS, digital compass, velocity meter, or accelerometer which is embedded in the device to provide data based on your location.

Click on the red icons to see the examples, then "Go Back"

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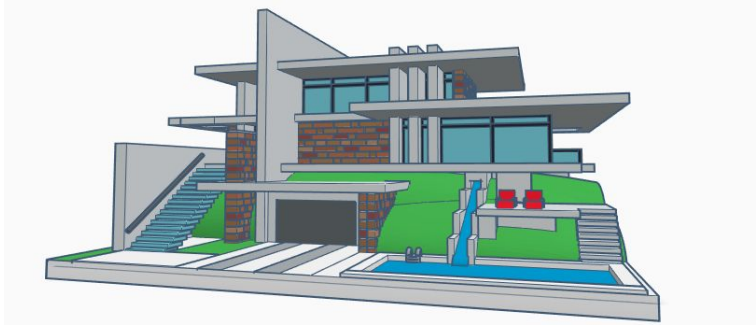
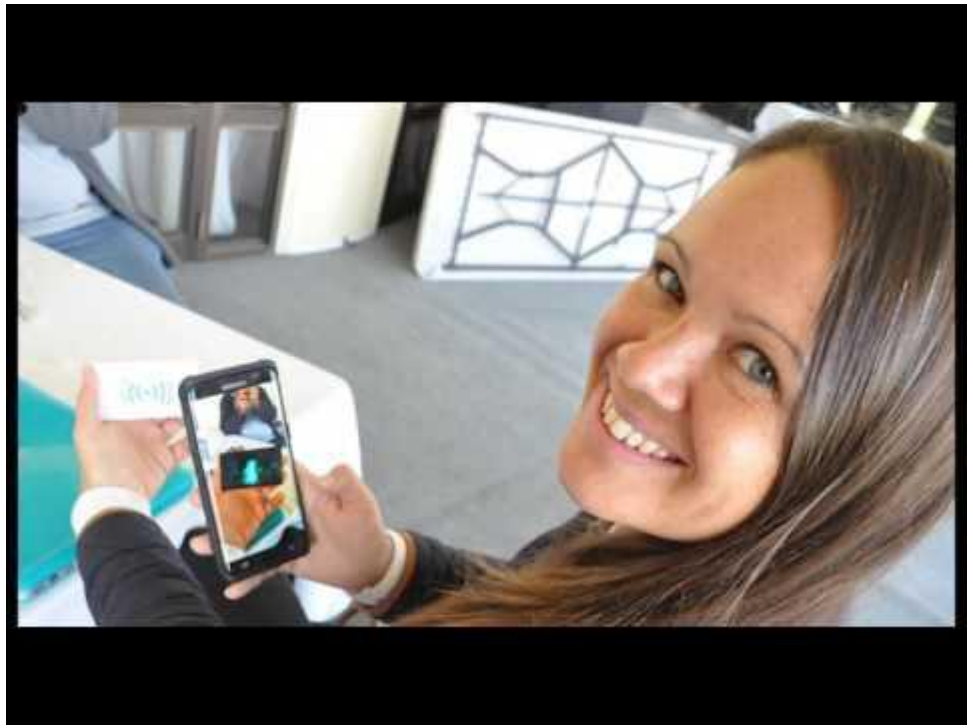
- Marker/Image Based AR ⟶ Camera+Visual marker

Indigital Storytelling

Types



Going further and creating your own App



Indigenous Storytelling using AR

https://www.kickstarter.com/projects/1064194723/indigenous-storytelling-comes-to-lifeindigital

Augmented Reality (AR)

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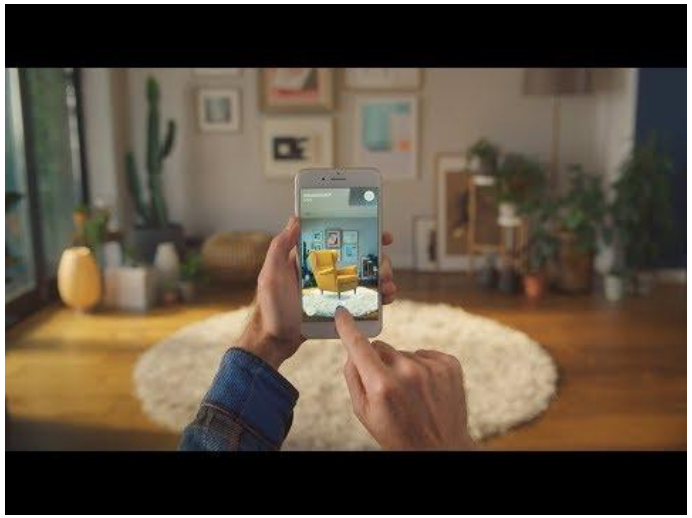
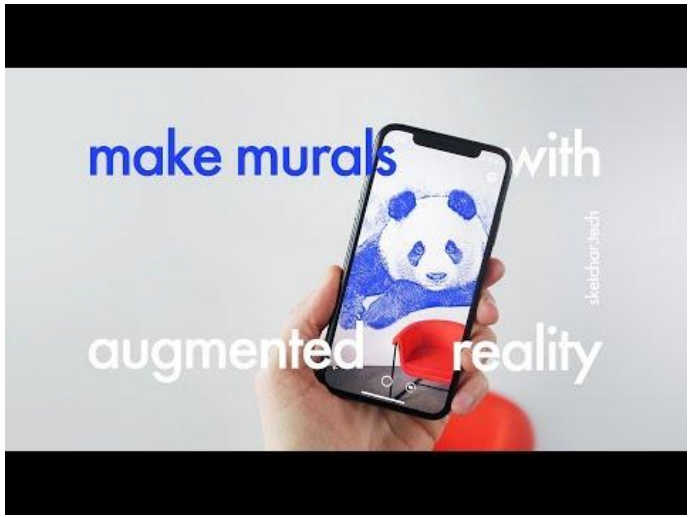
Types

- Placement → places 3D objects/ projections into the environment.





MOre On Sketch AR

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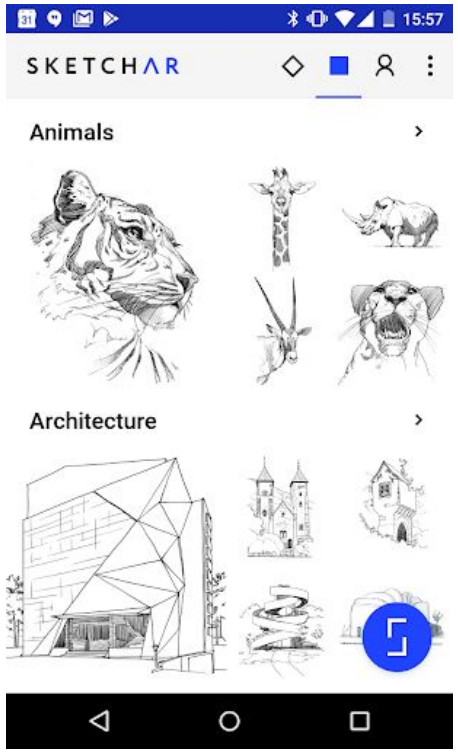
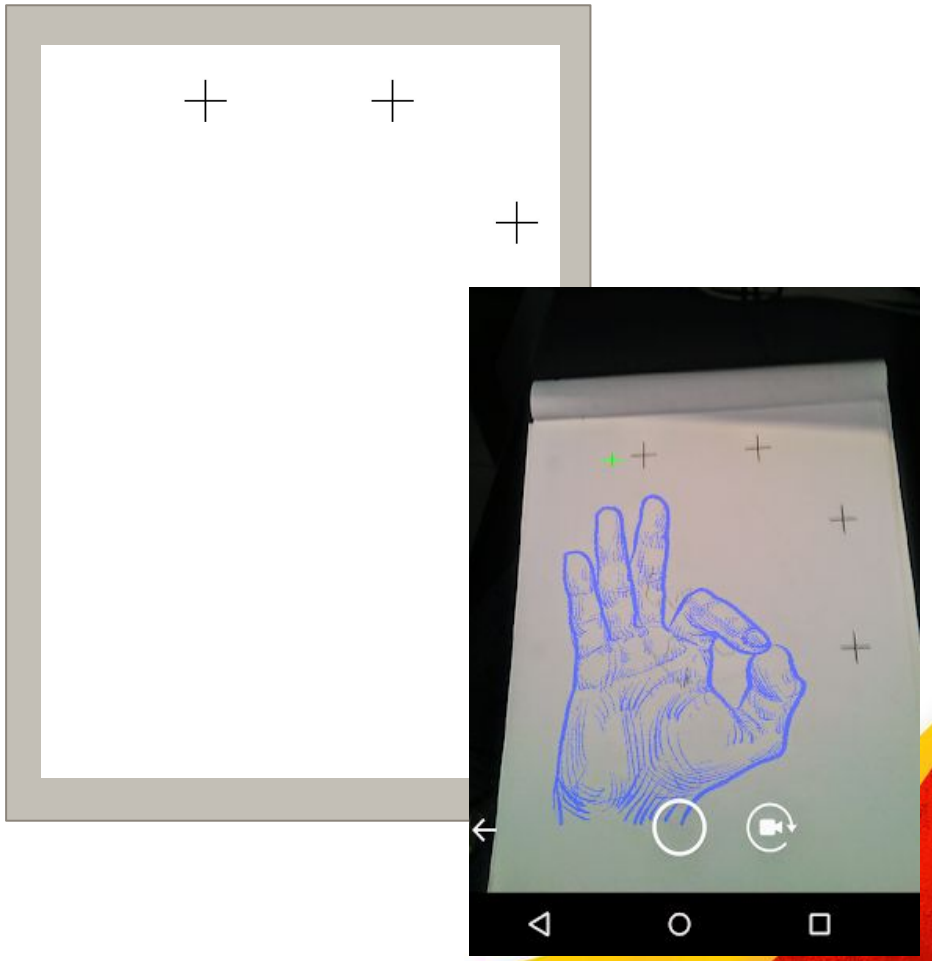
Step 1: Open de App

Step 2: Select your model



Step 3: Scan your working paper and draw!



https://www.media.mit.edu/projects/inertia/overview/

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More Examples!

https://er.educause.edu/blogs/2018/8/using-augmented-reality-to-promote-making-with-understanding

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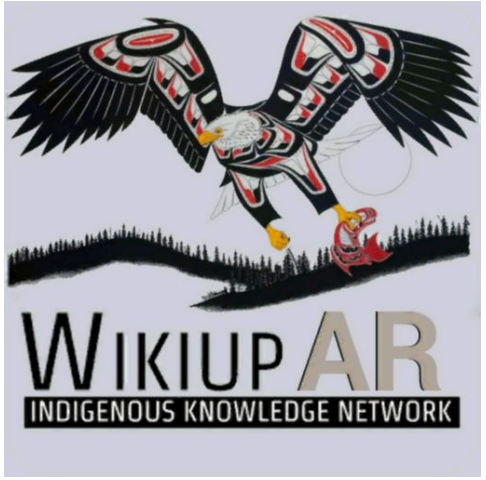

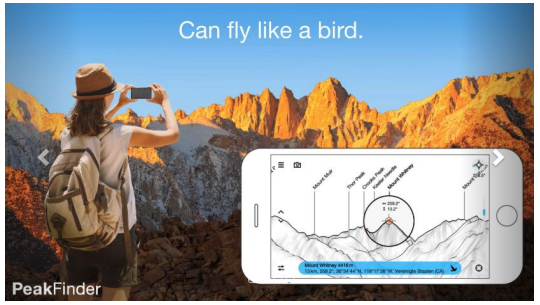

Types

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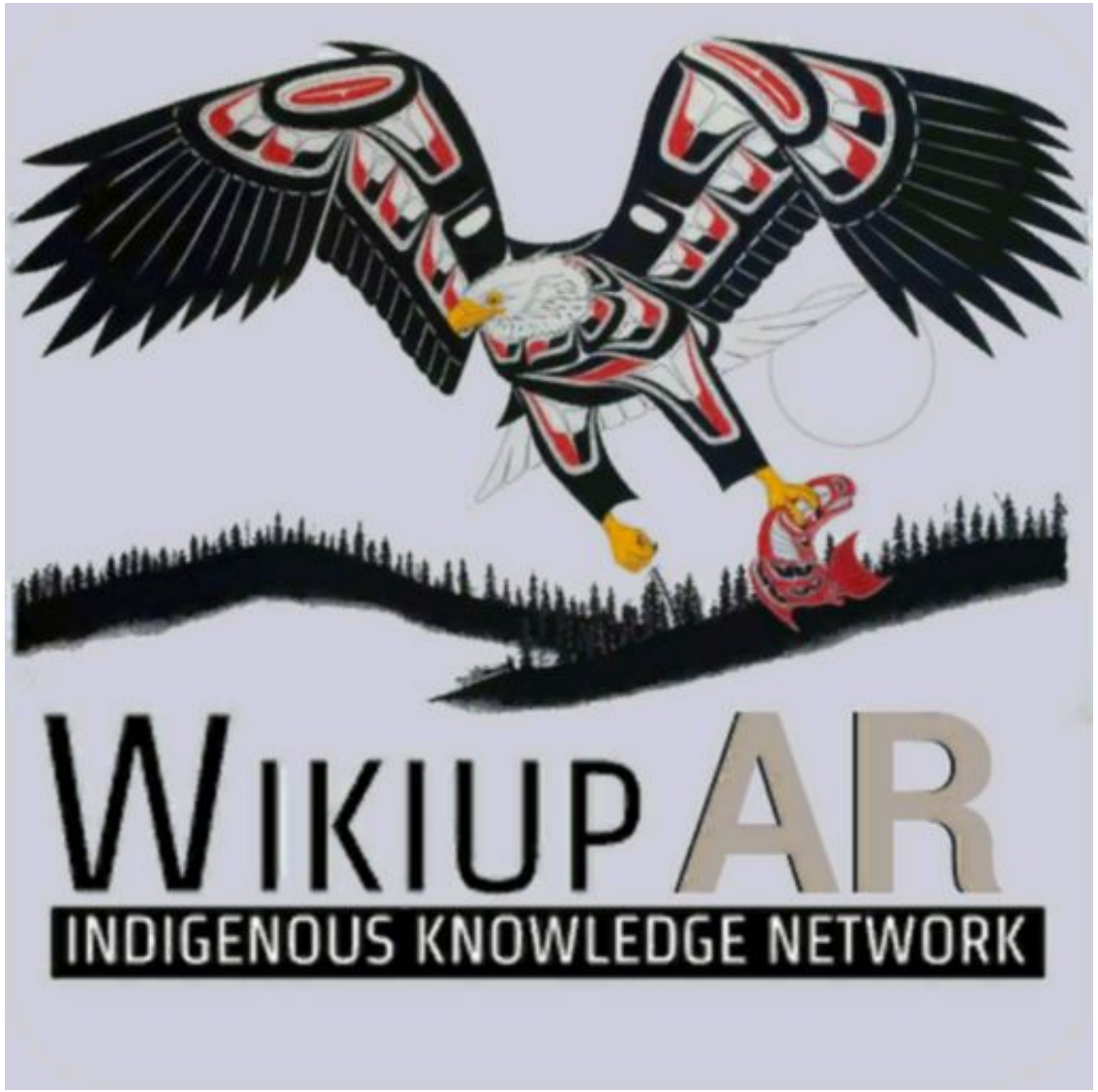

https://motherboard.vice.com/en_us/article/8qk9w5/augmented-reality-vancouver-indigenous

"We're hoping to interconnect Canada and unlock Canada through stories and legends”

“create something that is sustainable”

Here at UCalgary