Computation of
Three-Dimensional Electromagnetic Fields
# for an Augmented Reality Environment

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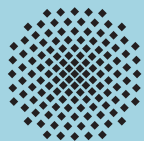
Motivation

- Maxwell's equations are difficult to understand for students

- 3D figures contain little information or are confusing

- Electromagnetic fields are invisible

- Efficient solution of 3D problems with modern software tools (e. g. COMSOL Multiphysics)

- Virtual reality (VR) and augmented reality (AR) are available

- Hardware: laptop computer, webcam, projector

Augmented Reality

Definition

- Mainly real objects

- Additional information by virtual objects
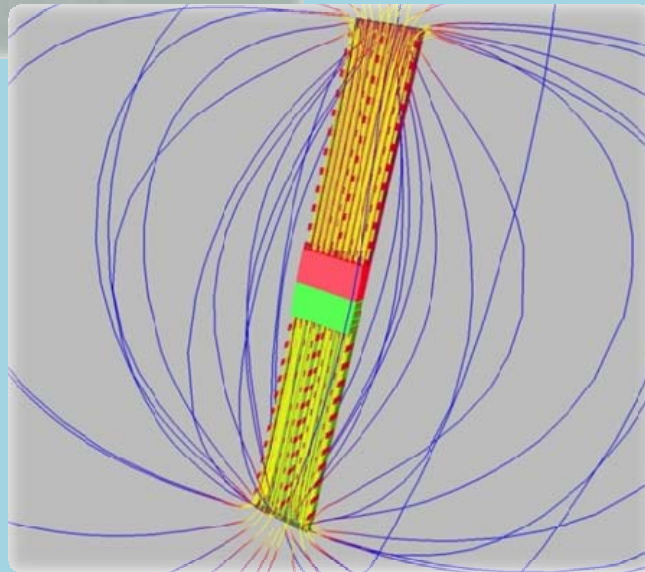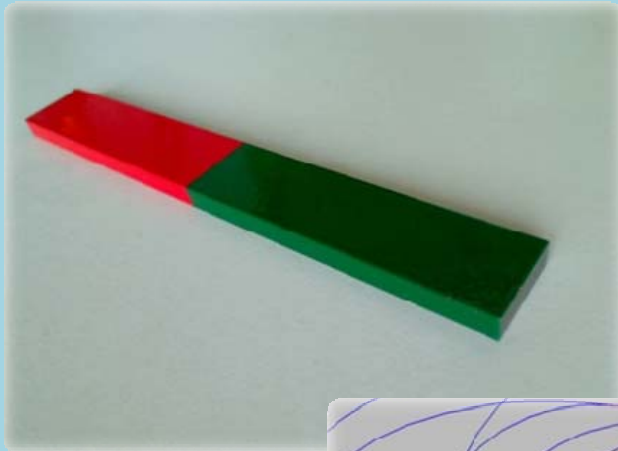
Augmented Reality

Visualization of electromagnetic fields

- Electric and magnetic fields are vector fields

- 3D problems

- Object of interest exists

- Fields inside matter $\Rightarrow$ virtual reality

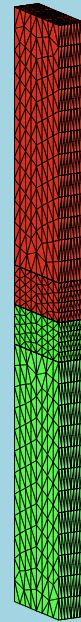- Fields in air or transparent matter $\Rightarrow$ augmented reality
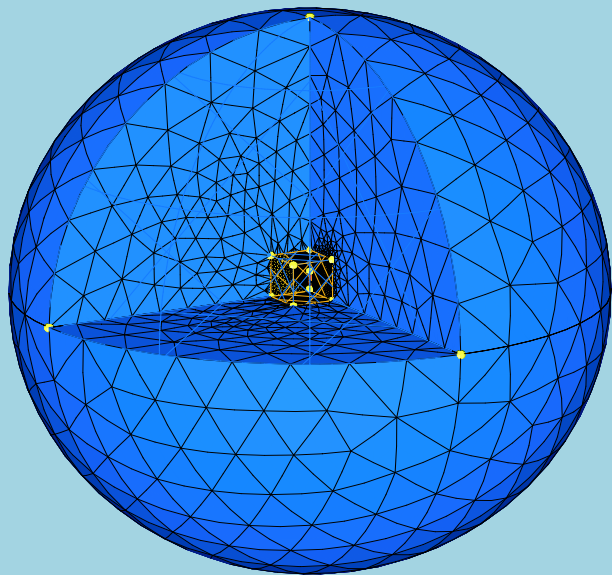
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Augmented reality environment
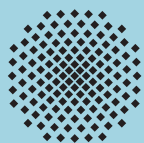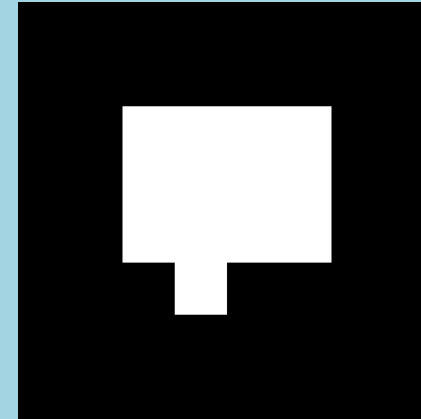
Augmented Reality

Computation of electromagnetic fields

- FEM or BEM

- Large air domain (evaluation points)

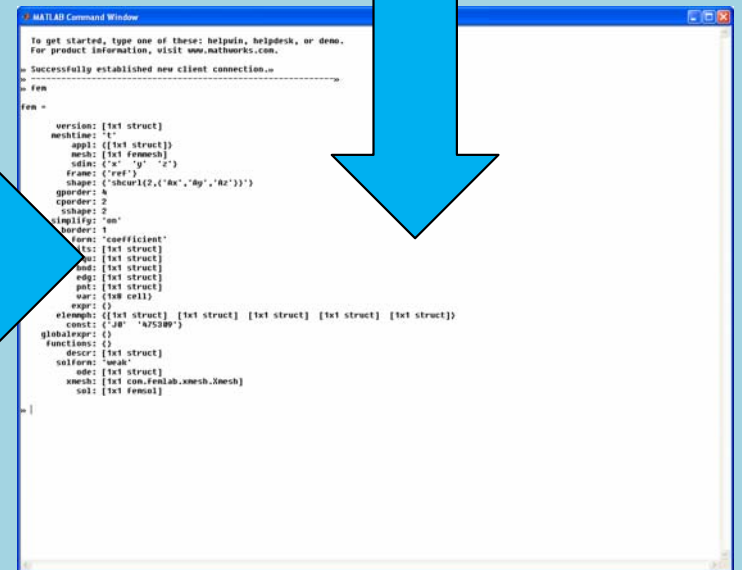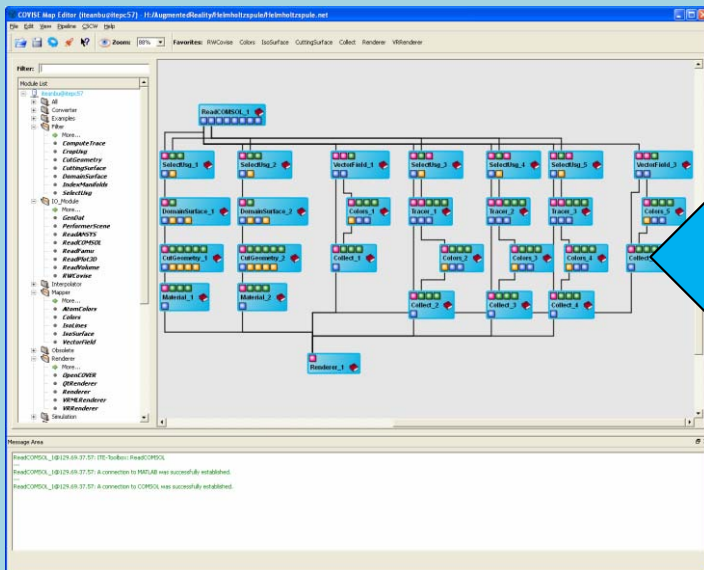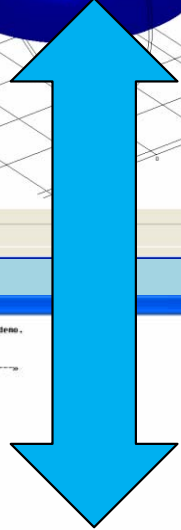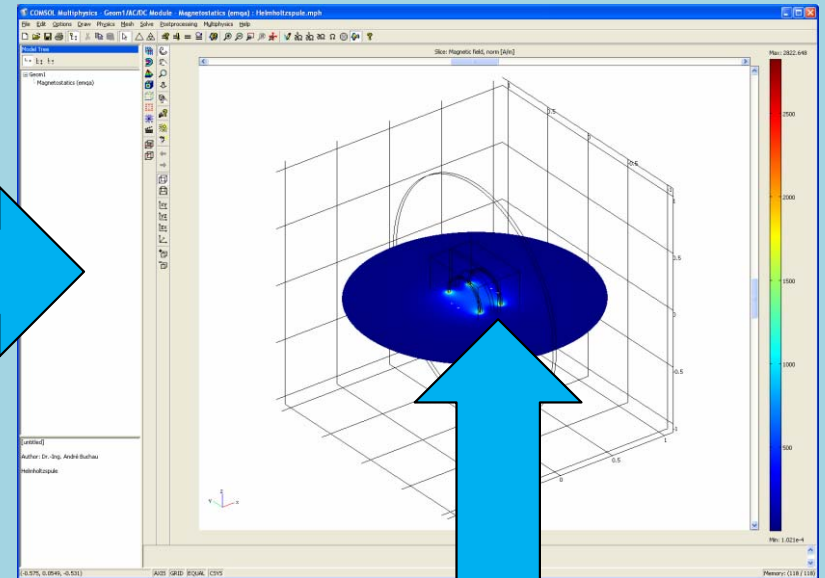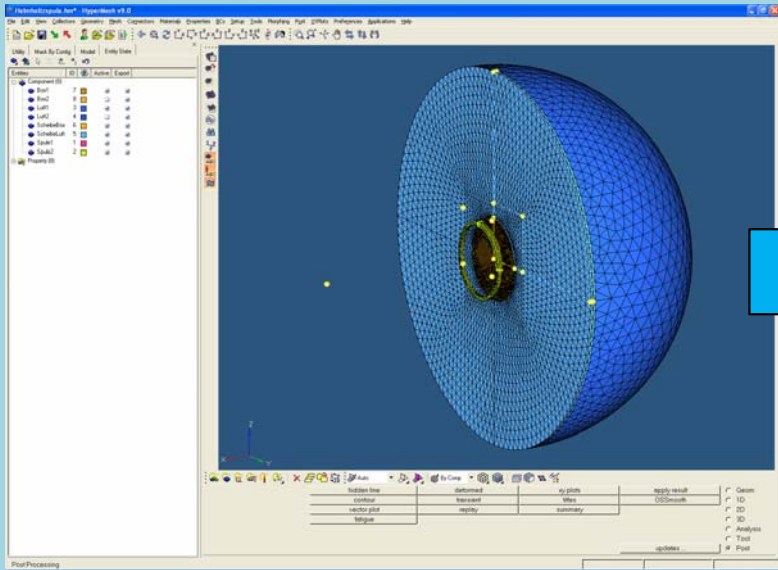- Split of computational domains simplifies parameter adjustment

Examples

Used hard- and software

- Altair HyperMesh (meshing tool)

- COMSOL Multiphysics (FEM code)

- COVISE (visualization tool)

- USB webcam (960 × 720 pixels, 15 frames per seconds)

- Laptop computer (single-core, 2.13 GHz, ATI Mobility FireGL)

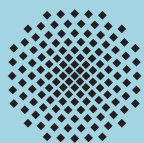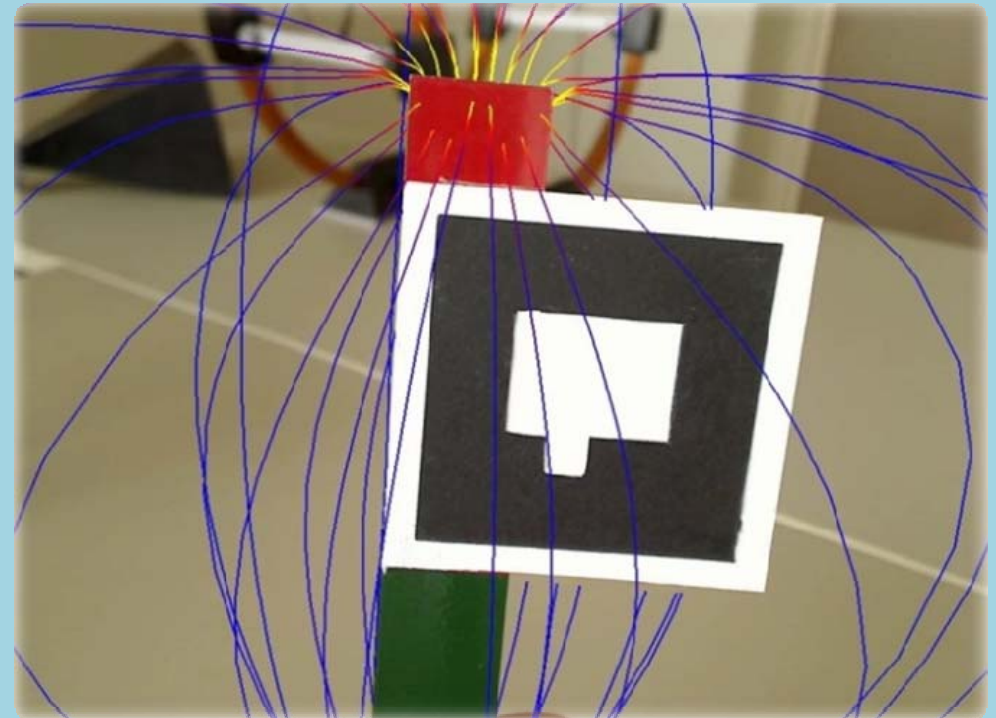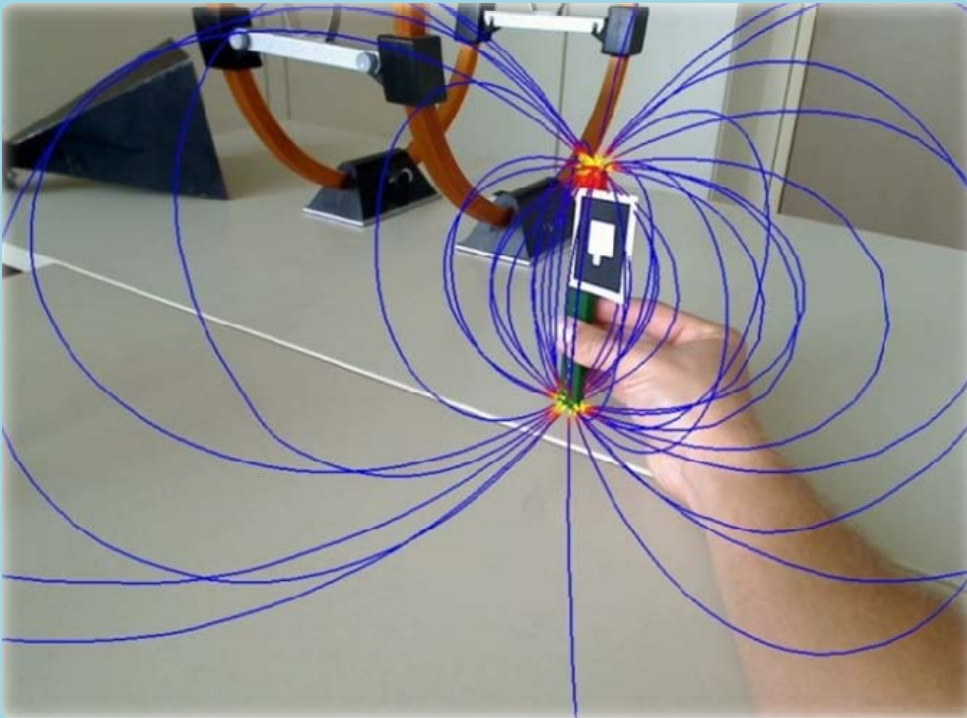- Projector

Examples

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COM
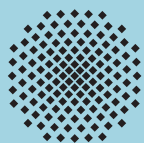
Examples

Studied examples
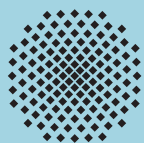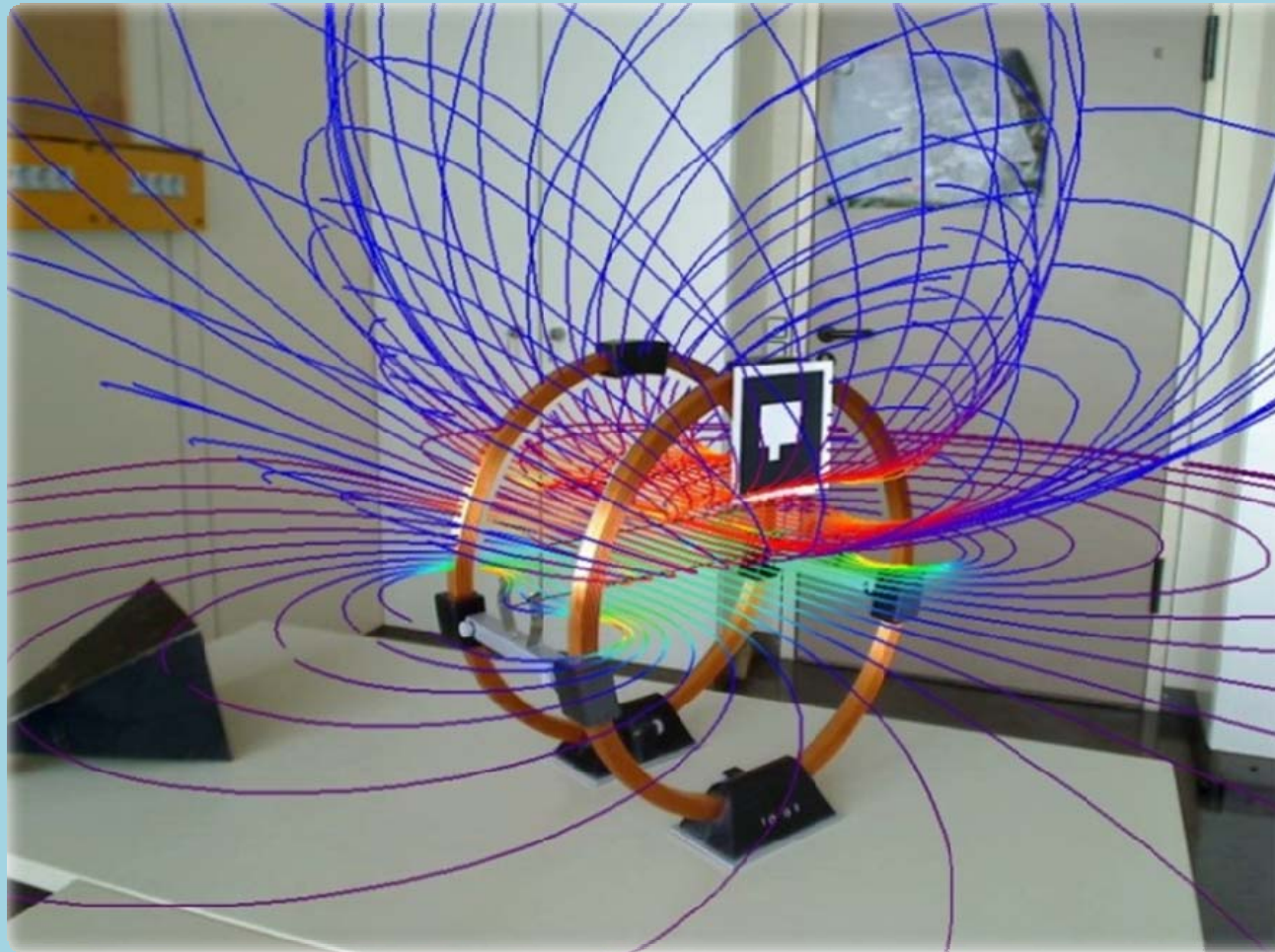
- Permanent magnet

- Helmholtz coil

- Horn antenna

Examples

Permanent magnet

Examples

Helmholtz coil

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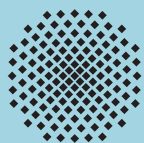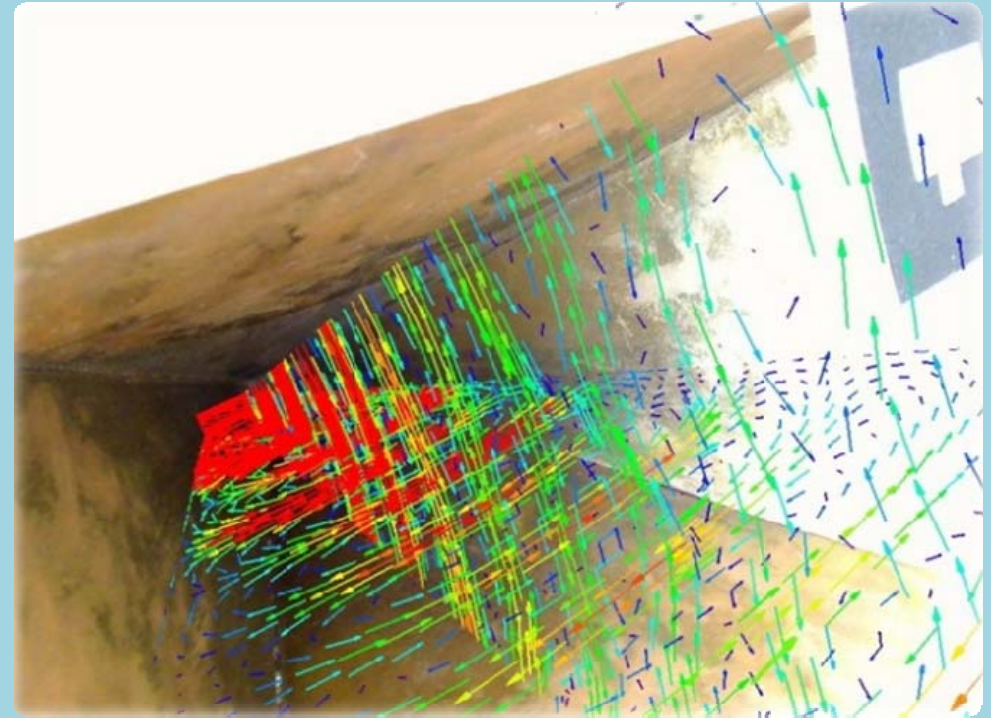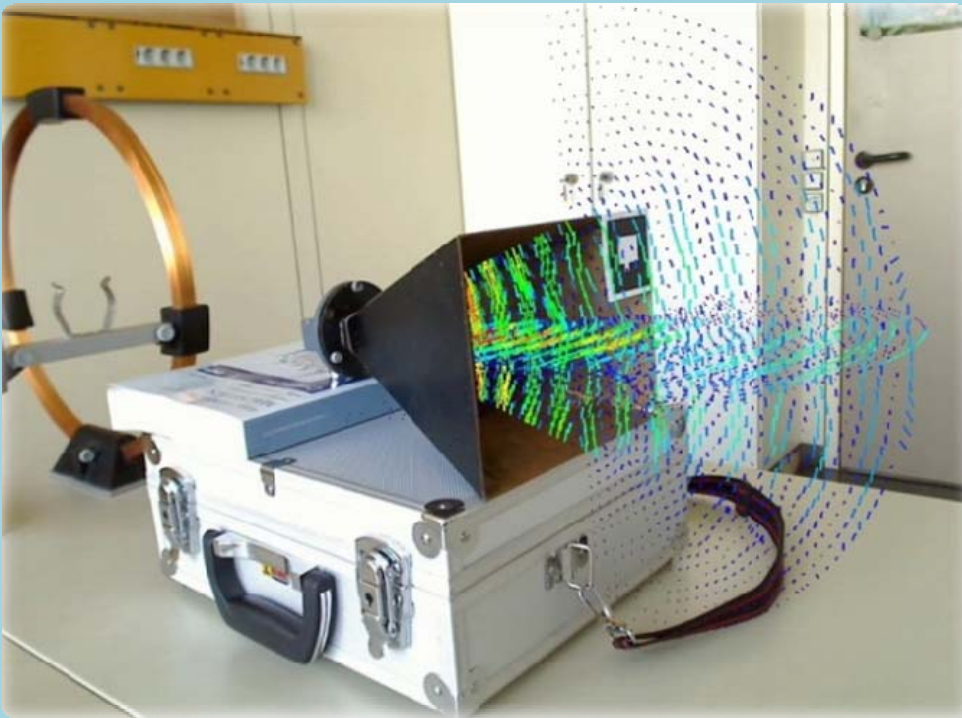# Examples

Horn antenna

Conclusion

- Augmented Reality is predestined for visualization of electromagnetic fields in air

- Augmented Reality is easy to use in a lecture room

- Students can concentrate on physical effects instead of reading complex figures

- COMSOL Multiphysics is both easy to use in a classroom and is powerful to solve large 3D problems