Computer Graphics & Computer Vision State-of-the-art and the Future

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NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Augmented and Virtual Reality (AR/VR)

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Why Virtual Reality?

Immersion

Multi-sensory

Wide FOV

Dissociation

Fun

Realism

Cognitive Stimulation

Reduce anxiety

Entertainment

Simulation

Engagement

Education

Augmentation

Memory and Motor Training

Motivation

Behavioural Change

Exposure Therapy

State-of-the-Art

- Entertainment
- Healthcare
- Training/Education (Flight simulators!)
- Visualisation

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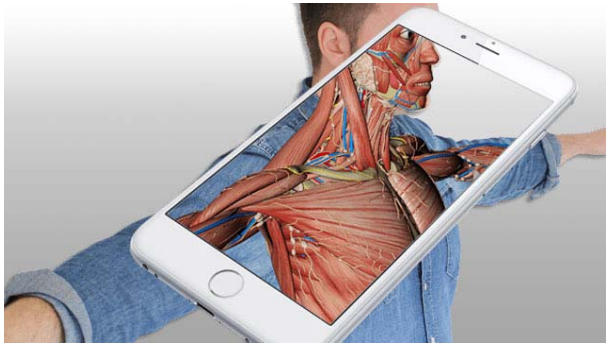

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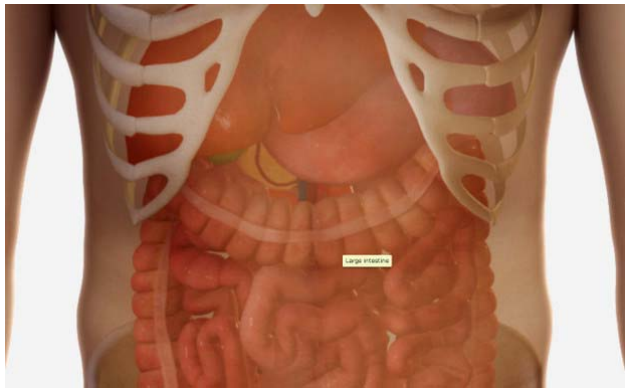

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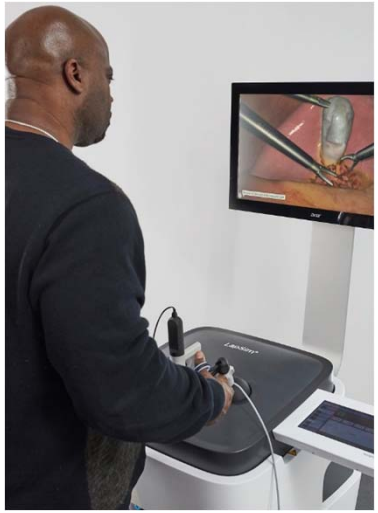

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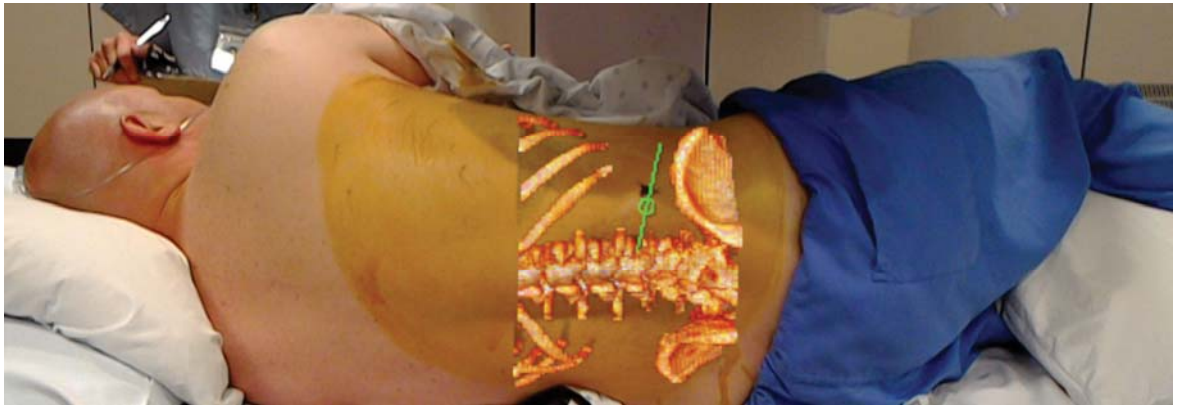
AR/VR Assisted Surgery

- Superimpose computer generated image on surgeon's view of operative field
- Used for urological and cardiovascular surgery and brain tumor removal
- OpenSight FDA approved
- Also used for surgical robots (De Vinci)



Q1: Why is it useful?

Q2: What are the risks/problems with this approach?

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The Future

- Simplify content creation
- Improve tracking & resolution
- Lighter & less obtrusive devices
- Improve safety & usability
- Focus on effectiveness
- Better interfaces
- Digital therapeutics

(https://www.ucsf.edu/news/2020/06/417841/fda-approves-video game-based-ucsf-brain-research-adhd-therapy-kids)

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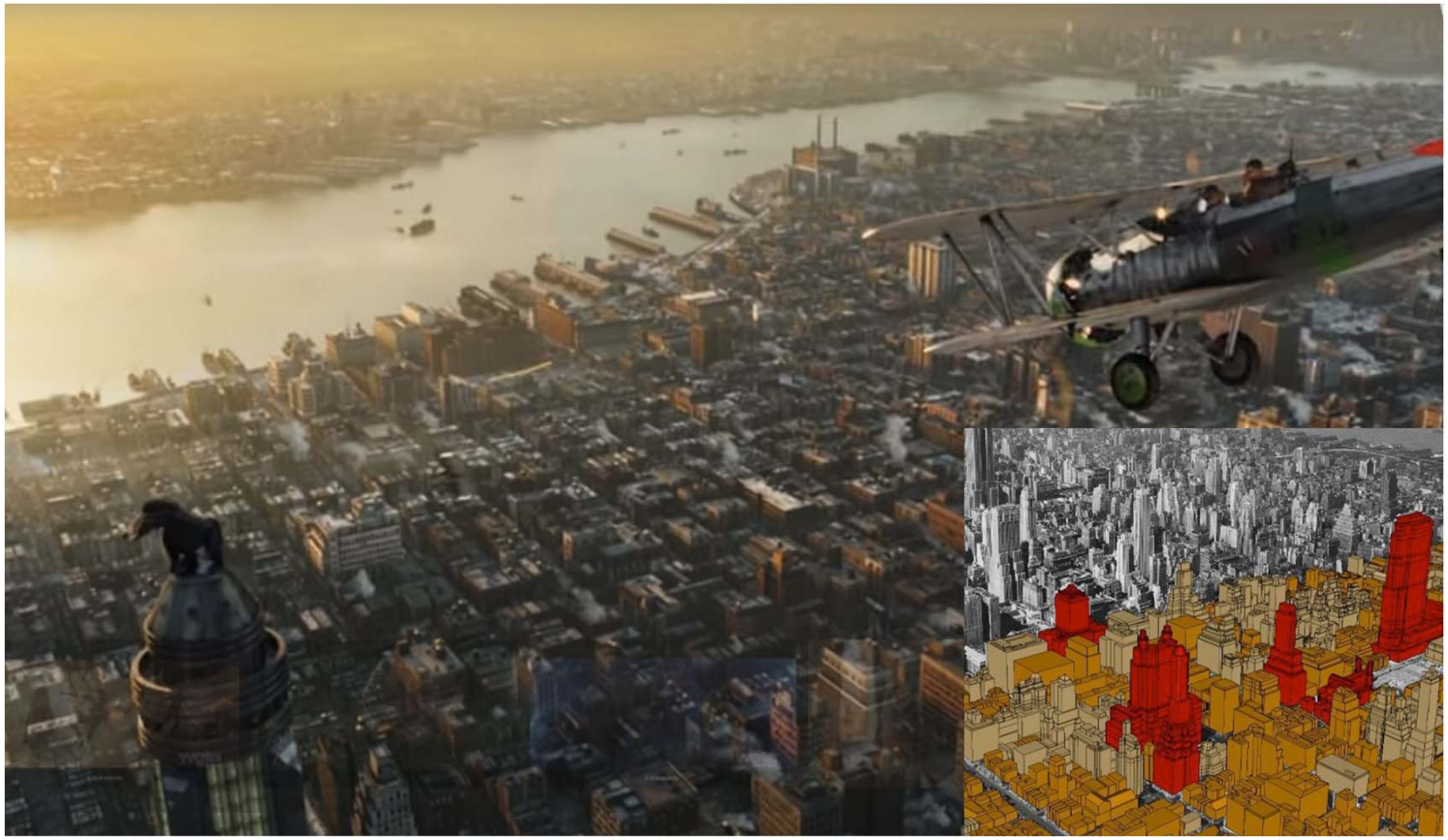
3D Content Creation

Procedurally Generated Content

- Create models from a set of rules
- Examples:
  - L-systems, Fractals, Perlin noise, Shape grammars, etc.
- Usually employs a basic “shape vocabulary”, which is used to built more complex shapes using rules
- Reproduction rules can be controlled by environmental parameters (position, terrain properties, etc.)
- Can be defined using different geometric and mathematical representations.

Procedurally Generated Content (example)

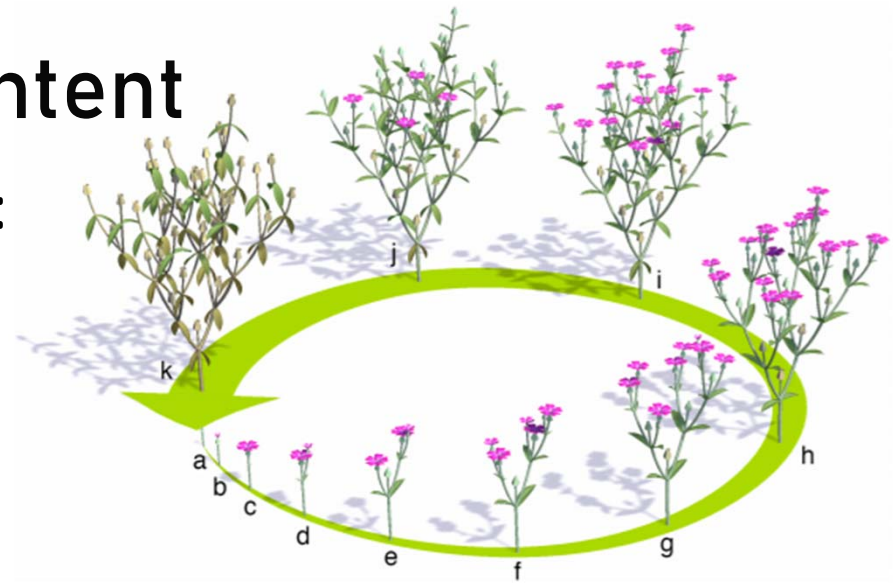


https://www.wetafx.co.nz/research-and-tech/technology/city-bot/

Procedurally Generated Content

State-of-the-art – improve realism by:

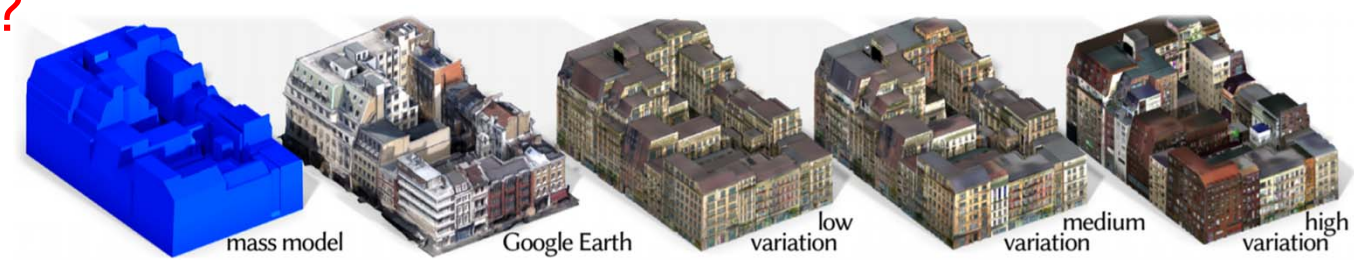
- Incorporating environmental and biological parameters to achieve realism
- Combining with neural networks to replicate characteristics of real-world entities



© 2018, Prusinkiewicz et al., Modelling plant development with L-systems

© 2019, Kelly et al., FrankenGAN: guided detail synthesis for building mass models using style-synchronized GANs

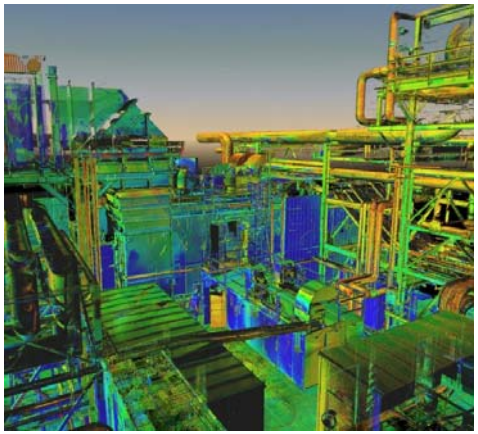
Q3: Why not use deep learning for everything?



3D Capture Technologies

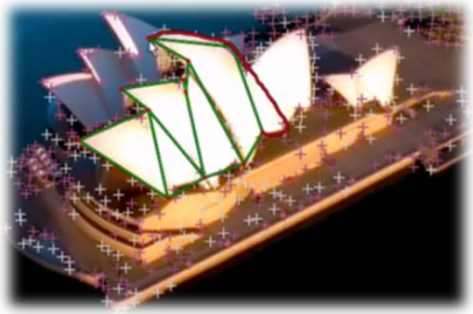
Binocular Stereo

Photogrammetry



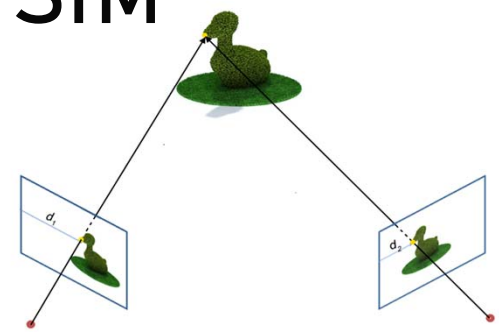
Laser Scanner

VideoTrace



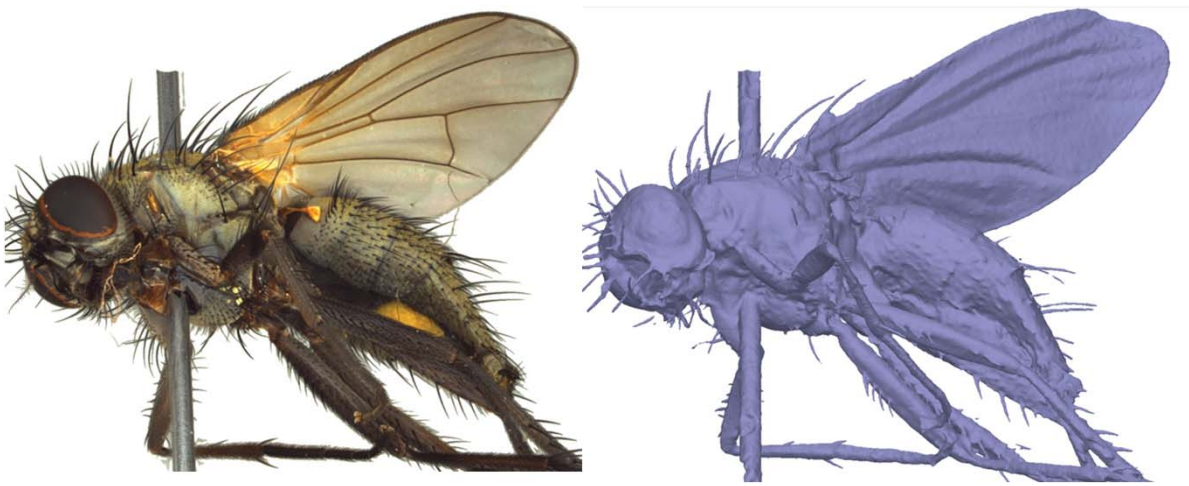
FaceGen

Image-Based 3D Reconstruction using SfM

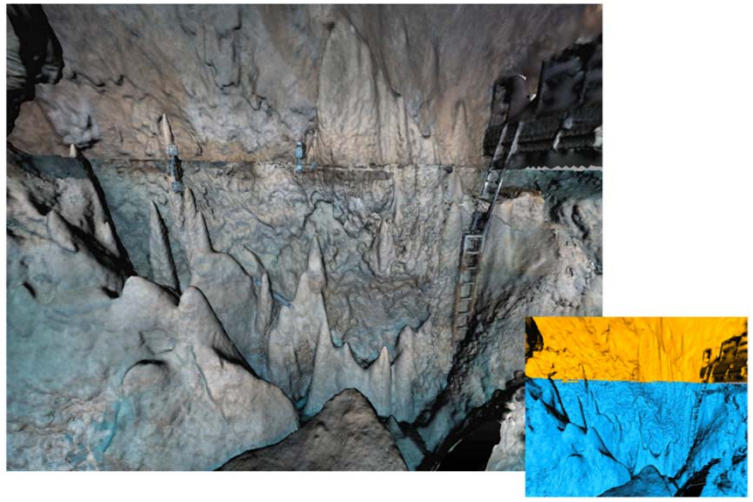


State-of-the art:

- Large-scale data and ultra-fine details
- Multi-source data integration
- Unusual environments (e.g. underwater, caves)



© 2018, Ströbel et al., An automated device for the digitization and 3D modelling of insects, combining extended-depth-of-field and all-side multi-view imaging

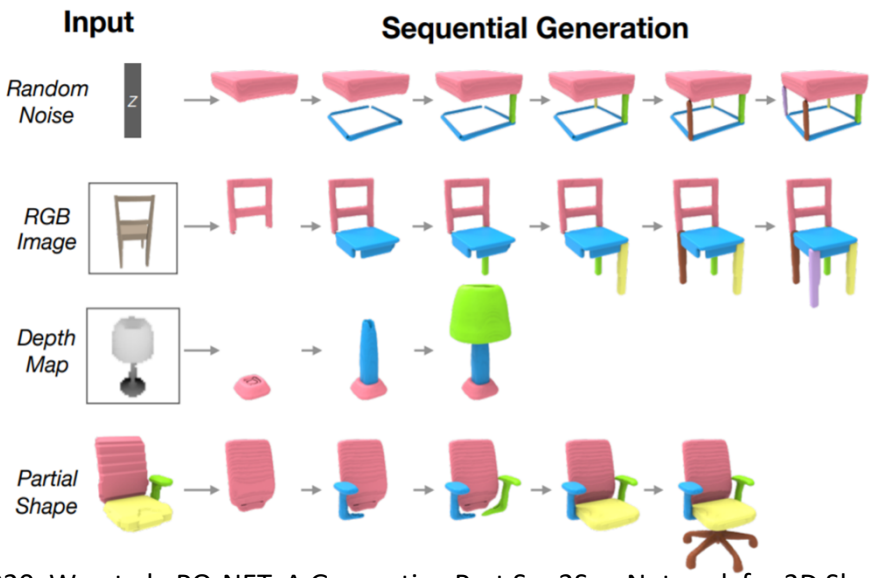


© 2020, Nocerino and Menna, Photogrammetry: Linking the World across the Water Surface

Image-Based 3D Reconstruction using CNNs

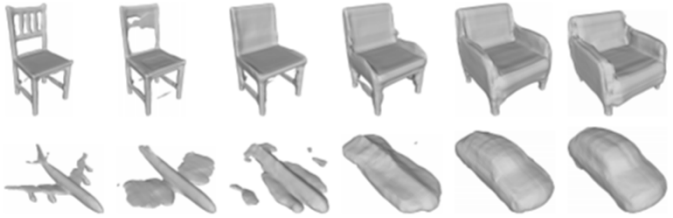
State-of-the art:

- Single-view reconstruction (Occupancy networks, shape partitioning, subspace parameterisation, etc.)
- Style transfer
- Domain-adaptive learning
- Part-assembly
- etc.



© 2020, Wu et al., PQ-NET: A Generative Part Seq2Seq Network for 3D Shapes

© 2019, Wang et al., DISN: Deep Implicit Surface Network for High-quality Single-view 3D Reconstruction

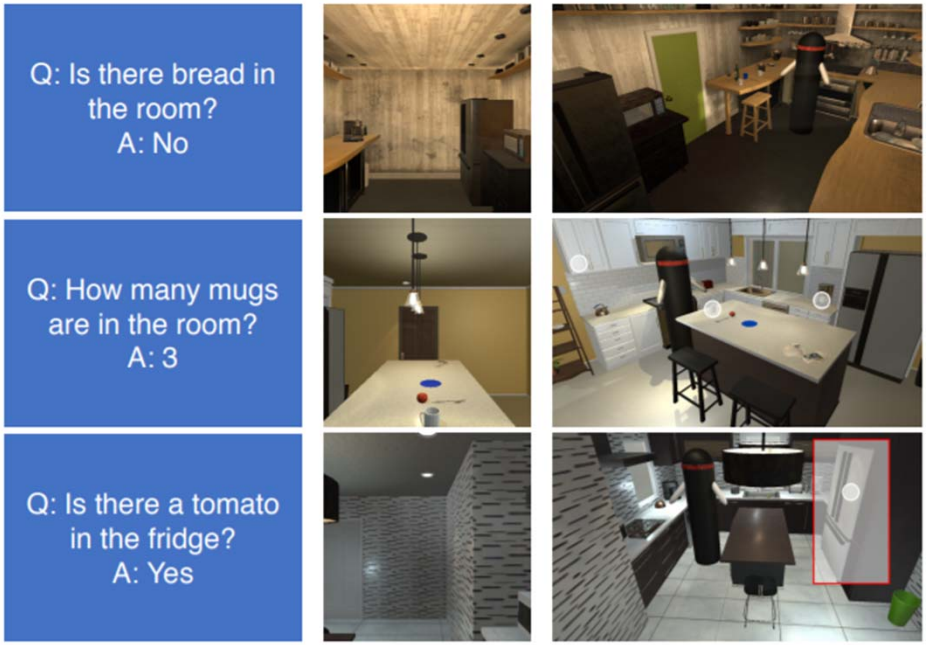


Q4: Why is traditional photogrammetry still superior in practice & why are people excited about the deep learning approach?

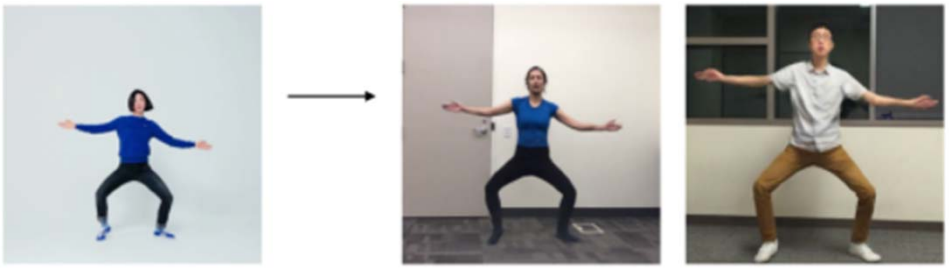
The Future

- Ultra large and fine scale
- Cheaper and simpler
- 3D Capturing of moving objects using ordinary cameras
- Real-time
- Semantic interpretation
- 3D Deep fakes

(https://carolineec.github.io/everybody_dance_now/)



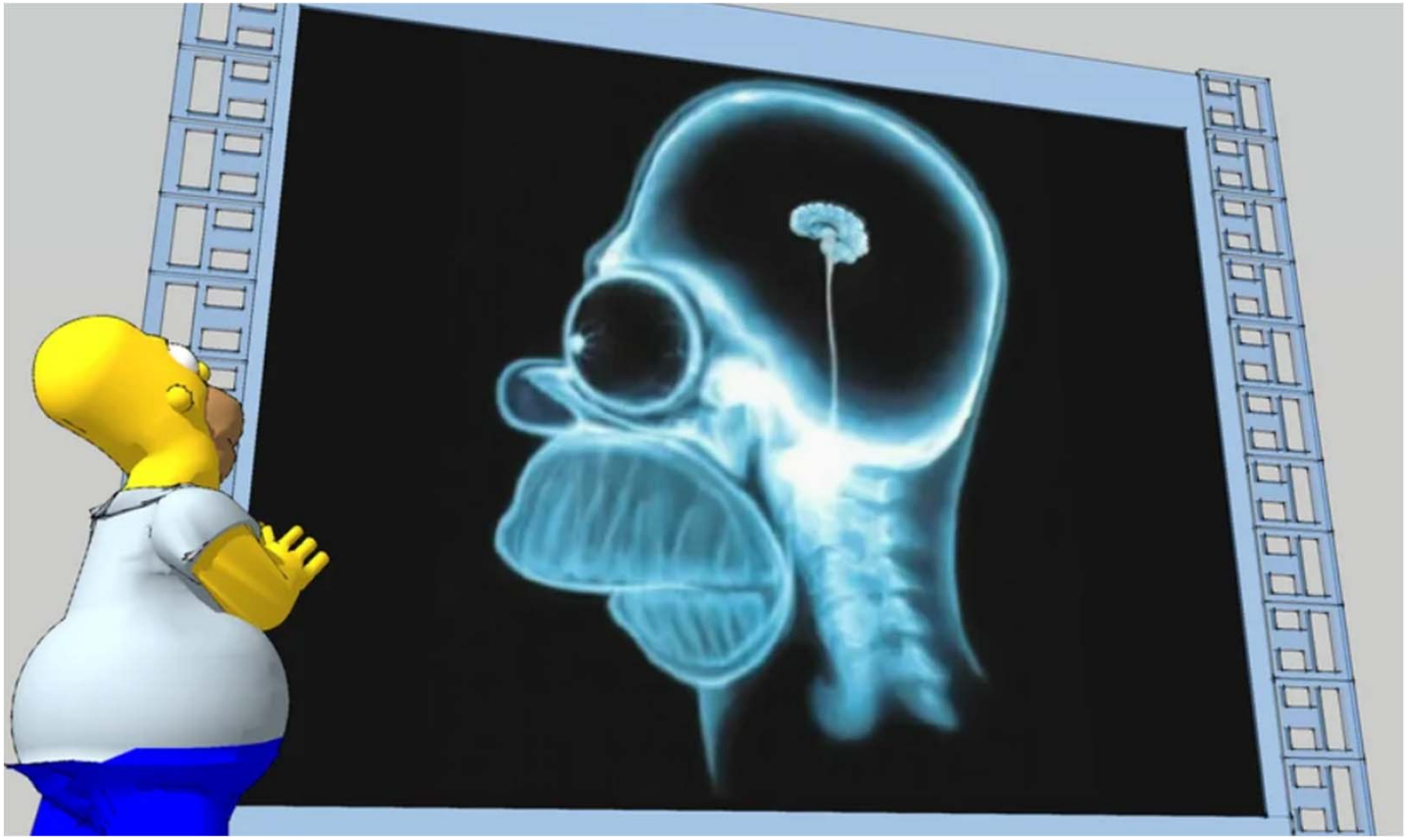
© 2018, Gordon et al., IQA: Visual Question Answering in Interactive Environments



© 2019 Chan et al., Everyobody Dance now

Q5: How does society best address deep fakes?

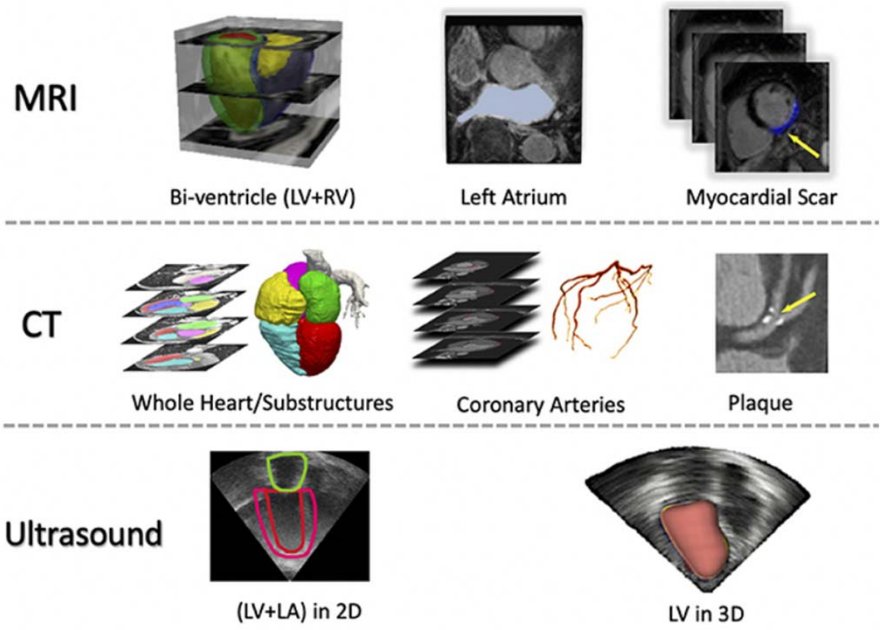
Medical Imaging

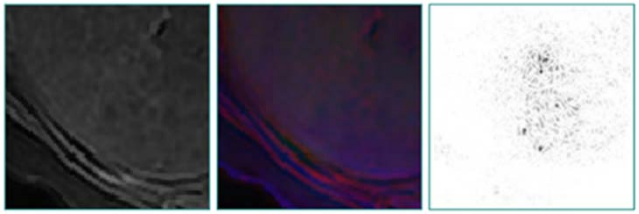


State-of-the-Art

- Sensor fusion
- Imaging of functional and molecular processes
- 3D reconstruction
- Analysis (segmentation) and diagnosis using deep learning
- Radiomics

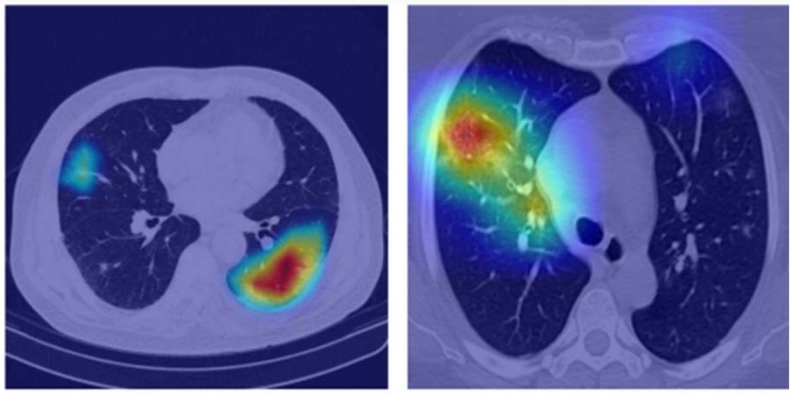
© 2020 Chen et al., Deep Learning for Cardiac Image Segmentation: A Review



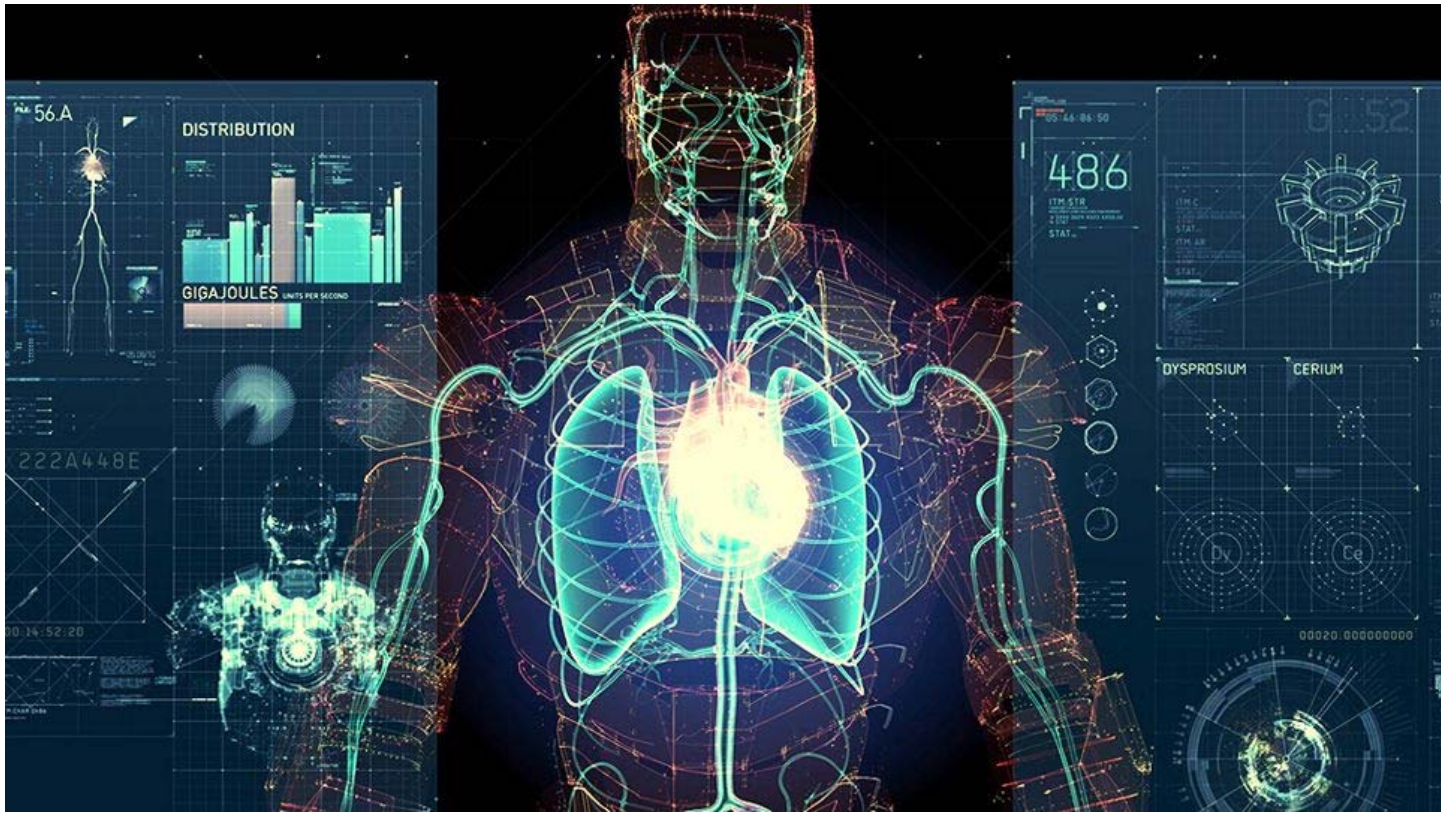


© 2020 Zhen et al., Deep Learning for Accurate Diagnosis of Liver Tumor Based on Magnetic Resonance Imaging and Clinical Data

© 2020 Ko et al., COVID-19 Pneumonia Diagnosis Using a Simple 2D Deep Learning Framework With a Single Chest CT Image: Model Development and Validation



The Future



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Q6: What do you think is the future?
Would you be comfortable with your diagnosis and treatment be made by a computer?

Expert Quote

"Deep learning AI is an innovative and fast moving field with the potential to improve clinical outcomes. Financial investment is pouring in, global media coverage is widespread, and in some cases algorithms are already at marketing and public adoption stage. However, at present, many arguably exaggerated claims exist about equivalence with or superiority over clinicians, which presents a risk for patient safety and population health at the societal level, with AI algorithms applied in some cases to millions of patients. Overpromising language could mean that some studies might inadvertently mislead the media and the public, and potentially lead to the provision of inappropriate care that does not align with patients' best interests. The development of a higher quality and more transparently reported evidence base moving forward will help to avoid hype, diminish research waste, and protect patients."

© 2020 Nagendran et al., Artificial intelligence versus clinicians: systematic review of design, reporting standards, and claims of deep learning studies