Artificial Intelligence and Microscopy

About Me

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Adam Sobieski is a researcher, developer, and entrepreneur. He brings two decades of experience to the exploration and analysis of forefront artificial intelligence topics. His professional interests also include the strategic forecasting of artificial intelligence trends and directions.

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Introduction

Digital Microscopes

Digital microscopes are utilized throughout biomedicine, the sciences, and education.

Mixed-reality Collaborative Spaces

Mixed-reality collaborative spaces are AR or VR environments intended for productivity.

Mixed-reality collaborative spaces enable users to interact with 3D data and to work together from multiple physical locations on shared tasks and projects.

Mixed-reality Collaborative Spaces

Mixed-reality collaborative spaces are device agnostic. Users can work together while making use of various AR, VR, mobile, and desktop computing devices.

For example, see: Microsoft Mesh.

Services

Services are computing resources which provide functionalities such as processing data or controlling devices.

Computer-vision-enhanced services, for instance, could process digital microscope data to perform real-time object, event, and activity recognition.

Services

Services could control digital microscopes' mechanisms and settings.

Services which both process data from and control digital microscopes could provide users with features such as automatic focusing, magnification, and tracking.

Services

Services could be client-local, on-premises, or remote.

Services could be free or paid, requiring a purchase or subscription.

Services

Services could be interconnected into graphs, or networks, by users.

Users might describe such systems by creating visual diagrams.

Multimodal User Interfaces

With mixed-reality collaborative spaces, users could interact with 3D content using their heads, eyes, hands, and voices.

Multimodal User Interfaces

Resembling how speech-recognition grammars can be dynamically generated from data, multimodal user interface layers could be generated and positioned atop displayed digital microscope content, allowing users to look, point, and speak to interact.

Multimodal User Interfaces

Computer-vision-related services can segment, recognize, and identify objects, events, and activities in data streaming from digital microscopes.

Segmented regions – be they bounding boxes or silhouettes – along with accompanying semantic labels could be utilized to create dynamic multimodal user interfaces.

Technical Discussion

Device Discovery

How can users in mixed-reality collaborative spaces find digital microscopes?

Device Description

What capabilities does a digital microscope offer?

How do users configure a digital microscope?

Service Discovery

How can users in mixed-reality collaborative spaces find services?

Service Description

What capabilities does a service offer?

How do users configure a service?

Interconnectivity

How can devices be connected to services?

How can services be interconnected into graphs or networks?

How can devices or services be connected to mixed-reality collaborative spaces?

Diagrams and Orchestration

As envisioned, users in mixed-reality collaborative spaces could create visual diagrams which represent systems wherein service graphs process live-streaming or recorded data from digital microscopes.

Orchestration is “the automated configuration, management, and coordination of computer systems, applications, and services.”

Optimization

Optimization topics include directing service consumers to specific servers for latency minimization and/or load balancing.

Streams

As envisioned, streams are produced by digital microscopes, processed by interconnected service graphs, and displayed in mixed-reality collaborative spaces.

Streams produced by digital microscopes might contain metadata which describe the instantaneous magnifications and timescales of their content. Such metadata would be useful for computer-vision-enhanced services.

Streams

Streams produced by services could contain annotation data, e.g., semantic labels.

With respect to annotating video streams, one could make use of secondary video tracks with uniquely identified bounding boxes or more intricate silhouettes defining spatial regions on which to attach semantic data using yet other secondary tracks. Similar approaches could work for point-cloud-based and mesh-based data.

Recordings

Live-streaming data from digital microscopes could be processed by service graphs. One reason for so doing is to enable users in mixed-reality collaborative spaces to interact with data via multimodal user interfaces.

Similarly, recordings from digital microscopes could be thusly processed and interacted with.

Artificial Intelligence

Computer Vision

Computer-vision-enhanced services could enhance visual data from digital microscopes, e.g., video infilling and video super-resolution techniques.

Computer-vision-enhanced services could provide real-time object, event, and activity recognition for contents from digital microscopes.

User Corrections of Recognition Results

With the flow of some usage-related data to interconnected services, these utilized services could learn from corrections made by expert users to computer vision recognition results.

Visual Perception and Comprehension

Question-answering systems could answer questions about content from digital microscopes.

Artificial Episodic Memory

Artificial episodic memory can allow systems to represent, index, store, search, retrieve, and remember previously perceived and comprehended sensory content.

Narrative Comprehension

With visual perception, comprehension, and artificial episodic memory, systems could answer multi-hop questions which involve combining directly observed and inferred knowledge from presently and previously perceived and comprehended sensory content.

Multimodal Dialogue Systems

Beyond multimodal user interfaces, beyond question-answering systems which exhibit perception and comprehension, we can consider multimodal dialogue systems for assisting users in their shared tasks and projects.

Related Standardization Work

Internet of Things

“The Internet of things (IoT) describes physical objects (or groups of such objects) that are embedded with sensors, processing ability, software, and other technologies, and that connect and exchange data with other devices and systems over the Internet or other communications networks.”

Internet of Media Things

“Internet of Media Things (IoMT) has the potential to change our world through massive-scale data exchange. But synchronization and interoperability are vital for this to work. ISO/IEC 23093, the series of International Standards for the Internet of Media Things developed by ISO and the International Electrotechnical Commission (IEC), provides the requirements and common language to enable media devices, applications and services to work together, outlining an architecture and specifications for the effective flow of data between media things.”

Web of Things

The “Web of Things (WoT) describes a set of standards by the W3C for solving the interoperability issues of different Internet of Things (IoT) platforms and application domains.”

DICOM

“DICOM — Digital Imaging and Communications in Medicine — is the international standard for medical images and related information. It defines the formats for medical images that can be exchanged with the data and quality necessary for clinical use.”

Workgroup 23 (WG-23) is chartered “to identify or develop the DICOM mechanisms to support AI workflows, concentrating on the clinical context. This includes the interfaces between application software and the back end DICOM infrastructure.”

MPAI

"MPAI – Moving Picture, Audio and Data Coding by Artificial Intelligence – believes that universally accessible standards can have the same positive effects on AI as digital media standards and has identified data coding as the area where standards can foster development of AI technologies, promote use of AI applications and contribute to the solution of existing problems."

Examples

A Droplet of Water

Let us consider a digital microscope magnifying and streaming imagery of the contents of a droplet of pond water.

Computer-vision-enhanced services could segment, recognize, and identify microorganisms in this data.

With multimodal user interfaces, users could look, point, and speak to indicate precisely which microorganism(s) that they wished for the digital microscope to focus on, magnify, or track.

A Living Cell

Let us consider a digital microscope magnifying and streaming imagery of a living animal cell.

Computer-vision-enhanced services could provide annotations, labeling parts of the cell.

With multimodal user interfaces, users could look, point, and speak to indicate precisely which part(s) of the cell that they wished for the digital microscope to focus on, magnify, or track.

Conclusion

Motivation

Advancing digital microscopes and enabling their interoperability with mixed-reality collaborative spaces can equip biomedical professionals, scientists, and educators, amplifying and accelerating their performance and productivity.

Device Calibration and Operation

Instead of users having to lean over microscopes and manually adjust knobs or levers – or having to sit at desktop computers to adjust on-screen sliders – artificial intelligence services utilizing computer vision could automatically calibrate and operate digital microscopes, allowing users to better attend to their shared tasks and projects.

Services, Streams and Recordings

Live-streaming data from digital microscopes could be processed by service graphs. One reason for so doing is to enable users in mixed-reality collaborative spaces to interact with data via multimodal user interfaces.

Similarly, recordings from digital microscopes could be thusly processed and interacted with.

Diagrams and Orchestration

As envisioned, users in mixed-reality collaborative spaces could create visual diagrams which represent systems wherein service graphs process live-streaming or recorded data from digital microscopes.

Multimodal User Interfaces and Dialogue

With mixed-reality collaborative spaces, users could interact with 3D content using their heads, eyes, hands, and voices.

Computer-vision-enhanced services could be of use for creating multimodal user interfaces atop digital microscope contents.

Beyond multimodal user interfaces, beyond question-answering systems for exhibiting perception and comprehension, we can consider multimodal dialogue systems for assisting users in their shared tasks and projects.

Thank you