



Augmented Reality for Enterprise Alliance



Preliminary Report on Identifying AREA Member Research Priorities

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TABLE OF CONTENTS

| | |
|---|----|
| Acknowledgements..... | 1 |
| Introduction..... | 3 |
| Increasing impact and value | 3 |
| Executive summary..... | 4 |
| Conclusions and recommendations | 4 |
| Diverse membership: diverse approaches to research | 5 |
| Non-commercial segment members and researchers “friendly” to AREA | 5 |
| Commercial/customer segment members | 5 |
| Commercial members’ topics of shared interest | 6 |
| Non-commercial members’ topics of shared interest | 7 |
| Appendix 1..... | 9 |
| Appendix 2..... | 10 |

INTRODUCTION

The benefits of executing joint research projects, sharing results and spreading research costs across members were a few of the original motivations for the formation of the AREA.

Today members can benefit from past and current AREA-directed and financed research projects on the following topics:

- Identifying and managing cybersecurity risks with AR-enabled systems
- Estimating Return on Investment from AR projects
- Assessing human factors and safety risks of AR in the workplace
- Reducing barriers to AR adoption in manufacturing
- Best practices when merging IoT, AI, and AR

INCREASING IMPACT AND VALUE

Responding to our members' growing and wide-ranging research interests The Research Committee invited members to contribute to a joint Research Agenda which will guide research by non-member organizations as well as member-led, AREA coordinated research efforts. This new workstream is in addition to continuing the current practice of AREA-directed and funded research projects (see list above) and will focus on overlaps in members of current research programs or roadmaps.

In order to formulate the first AREA Research Agenda without exposing specific members' strategic plans or other sensitive information, this initiative aimed to:

1. Detect and capture overlaps in research interests in a confidential manner
2. Explore new ways to share existing research resources for common objectives

A first step towards the above goals was to identify internal member research stakeholders and conduct interviews with them to capture:

- Members' research interests (their own research agenda) and possibly current research projects,
- Compile any (past) research work which could be relevant for and shared with other members of the AREA,
- Any recommendations or observations on research methodologies and suppliers

In parallel, this project aims to identify and capture the research interests/programs of AREA academic members and their availability/capacity to support and/or conduct a series of interviews to inform the AREAs' Research Agenda.

The series of interviews took place between April - June and focused on

1. Enterprise customer (buyer) members
2. Non-commercial/academic members
3. A small sample of OEM members

EXECUTIVE SUMMARY

Members are in agreement that more research is needed. Everyone is keen and enthusiastic about learning more but the ability to participate in or contribute to new or ongoing research is frequently hampered by varying objectives, resources and the members' need for confidentiality. Confidentiality policies and the involvement of multiple stakeholders in decision making for AR investment also limits the ability to identify specific projects for joint research that would benefit multiple members. This said, the AREA interviewed some of the best academic AR researchers for this project and there are ways to leverage them or collaborate more for the benefit of members.

There is one exception to the above: the topic of "Scalability." This is a large, overarching concern of many members. It has multiple components or facets including concerns about the economic impact (pricing/costs, ROI), technical impacts (security, systems integration and interoperability among others) and concerns about the ecosystem (vendor qualification, long term stability), with a strong focus on operations (changes in SOP).

A new initiative focusing on taking AR to scale would be well received by AREA members, however, the format(s) for conducting research and disseminating results is unclear. Tradespeople wearing AR displays will receive accurate work instructions in context with the tasks they are performing. If and when necessary, they will be able to receive assistance from a remote expert. If there are any changes to the Standard Operating Procedures, these will be rapidly and centrally updated via technical publication systems.

CONCLUSIONS AND RECOMMENDATIONS

Due to the various sensitivities and very diverse membership, creating a universal and overarching Research Agenda is a challenge. Pragmatically, the process should focus on narrowly defined, very specific questions rooted in the domains on which various committees are already working with one notable exception: **Scalability**.

Specific recommendations

1. Delegate to Committees (Security, Safety HFIG, etc) the submission of the top two or three topics of interest in the form of specific research questions
2. Work with academic/non-commercial members and other non-members on reviewing past, unpublished (custom) research to determine utility for AREA Members. Develop an AREA process and template for research which has been obtained/received in this fashion and have the Research Committee serve as a publisher (vehicle for the dissemination of research)
3. Articulate concerns and questions around the issue of "Scalability" into a dedicated platform
4. Conduct interviews with additional members (especially, the Providers segment) to round out the findings

Diverse membership: diverse approaches to research

Despite the lukewarm reception of the published Draft Research Agenda (judging by the relative lack of comments or suggestions in a shared document), our conversations confirmed that members unanimously believe that the industry needs more research. “Research is a good idea” as one of the respondents opined. However, there is less consensus about the kind of research, or the topics using which methodologies, or what “research” even means.

Approaches and attitudes related to research are scattered on a wide range. The greatest difference (probably not a coincidence) was between the for-profit (commercial companies) and non-commercial members.

Non-commercial segment members and researchers “friendly” to AREA

This group includes bona fide academic researchers with a long history and great pedigree in the field. Although this was not a data point we formally tallied, quite likely those interviewed embody the most/longest experience in various “flavors” of AR by a factor of 3x-6x. Generally speaking, the work of these renowned researchers is in the public domain, their interest, focus, and orientation are easy to discern.

Commercial/customer segment members

In contrast, this group couldn’t be more diverse. On one end, there are OEM members whose primary business is focused on creating value propositions in or specific to AR, and they tend to have more robust research efforts, lot of primary data collection efforts, rigorous methodologies, highly specific, typically confidential roadmaps, frequently supported by meaningful budgets and dedicated organizations. However, the scope of “research” for these organizations goes far beyond that of the AREA’s mission (“...to achieve greater operational efficiency through the smooth introduction and widespread adoption of interoperable AR-assisted enterprise systems”) covering tangential, even unrelated domains.

At the other end of the spectrum are members who perceive AR as one of the many tools to apply on their own digital transformation in a specific industry vertical. They are omnivorous. They are more likely to accept and use secondary data collection methods, combining various sources of information with skunkworks projects on a shoestring budget, erring on ‘speed’ as opposed to ‘rigor’, frequently in reaction to time-sensitive issues or deadlines.

This is not a coincidence: research, at its heart, is about decreasing risks associated with a (business) decision. The greater the risk for an organization related to a particular subject, the more articulated (research) efforts are likely to support the decision-making processes. This creates a spectrum on just about every aspect of research: vocabulary, terminology, taxonomy, scope, methodology, and time/quality tradeoffs.

On a different note: another topic that came up frequently is the lack of availability of research respondents. A challenge most members face when launching a quantitative project is access to respondents with the right kind of first-hand experience. Putting it differently: workers on the

front lines who have had “enough” experience with a particular device or use case to form opinions AND are in a position to share their experiences are very rare (and valuable).

Commercial members’ topics of shared interest

Despite different approaches and emphases, there are a number of domains that are of interest to almost every customer segment member interviewed for this study - albeit to different degrees. Considering the low sample size the following list does NOT reflect the order of priority.

Scalability

As discussed above, this is a broad topic. Concerns articulated during interviews centered partly around technical suitability of current solutions to be deployed at scale: systems integration, interoperability, capacity, and compatibility. It also extends to policies and regulatory issues and concerns about the larger ecosystem, its long-term reliability/dependability and lack of partner maturity. A common theme articulated by one of the respondents: “There’s a conflict between the need for small companies to develop fast/fail fast and how a large enterprise does business: speed, time horizons, geographic range (language, regulatory) and the ability to service.” The topic of market transparency is also of interest: specifically, the lack of vetted information sources to support specific claims of vendors and the forecasts of industry analysts.

Economic Impact

Defined and articulated a few different ways, the underlying interest is to understand, prove and quantify the impact AR has in vastly different enterprise settings. It is not so much an “IF they need AR” question as much as questions about “HOW MUCH?” or “HOW QUICKLY?” This topic includes subjects like highest ROI use cases, clarity in costs/pricing for unclear offerings, measuring changes in productivity in a company-specific environment or the larger economic impacts (e.g., lower risk, lower training).

Safety

Safety comes up in two different contexts. On the one hand, it means ensuring safe operating conditions for workers - perhaps one of the strongest use case for AR. Training/practice ‘offline’ (e.g. with mock equipment), freedom of both hands or reducing operational risk, in general, are the most frequently mentioned attributes. On the other hand, it is understood to be about the safety of the AR solution deployed - an approach that ensures the particular modality of deployment a company chooses will not be detrimental to worker safety. This topic frequently crosses over to the Human Factors domain, typically concerning UX/UI. Examples like selecting the right hardware (e.g. not blocking peripheral vision or devoid of attached cables) or understanding cognitive impact.

Human Factors

There is a strong interest in Human Factors which would likely grow stronger if and when the Provider segment’s input is gathered as part of this research. However, the specific subjects of highest interest tend to be reflective of a member’s position in the ecosystem. For example, OEMs may be interested in determining which AR KPIs related to tracking, graphics rendering,

and display are most important to the UX while end-user organizations are more interested in utility tradeoffs between binocular and monocular devices, or gesture- or speech-based control.

Security

This may be the most uniform interest across all groups and it is most closely related to “Scalability.” Not surprisingly, this is one of the most ‘notorious’ inhibitor towards moving from pilots to (large scale production) and frequently refers to a mix of active (i.e., penetration testing, bug bounty programs, etc) to passive (frequent patches, transparent/exhaustive documentation, etc) assessments.

Sharing and Collaboration

All members interviewed for this study are interested in sharing content or collaborating on future projects but the need to preserve proprietary information frequently creates roadblocks. Customer segment members in particularly sensitive industries are the least likely to be able to open up about or contribute to broad research topics but may be able to participate in or collaborate on narrowly-defined, non-strategic, very specific topics among non-competitive members.

Non-commercial members’ topics of shared interest

In the past few months, the AREA offered to members a detailed view of the portfolio, research capabilities and sample projects of our member, Embry-Riddle Aeronautical University and other well-known academics in our space. Below is a small but representative sample of Prof Barb Chaparro and her team’s work and similarly, we list links to non-member academics in the attachment. Many of these institutions have first-hand experience with various large corporations, defense department projects, and other real-world applications influencing the direction of various large enterprises.

Barb and other interviewees have expressed a strong interest in working with AREA members and can provide varied research services like study design and execution, a literature review or meta-analysis. Embry-Riddle’s focus is - generally - on Human Factors (UI/UX) but others also cover related technologies (e.g. object tracking).

Typically, research work is published and available in the public domain or for purchase from conference proceeding publishers. However, not all past work has been focused on or is a good fit for the AREA mission. At the same time, there remains unpublished work that is relevant for AREA purposes which - after some ‘scrubbing’ - may be made available for members.

A notable exception is our member EPRI, that focuses solely on the needs of its own members (the electric power industry). EPRI has a very robust and wide-ranging research program on its own and it is currently working on an AR related roadmap that will identify themes, possibly forming a basis of collaboration later this year.

Since our accomplished members tend to have a very long list of achievements we highlight here the work of our AREA member and an appendix contains information about other academics who were interviewed for this project.

[Barb Chaparro, \(PhD\): Professor of Human Factors at Embry-Riddle Aeronautical University, Leads the Research in User eXperience Lab \(RUX\)](#)

Sample projects

- Texting while driving using Google Glass™
- College Student Day-in-the-Life UX with the Microsoft HoloLens
- Text Input Baseline Study with the Microsoft HoloLens

APPENDIX 1

TEXT OF INVITATION MESSAGE TO RESEARCH OWNERS/STAKEHOLDERS

“The AREA Research Committee has a new initiative to study members’ research priorities [LINK TO NEW - ABOVE - WEB PAGE] in a manner that can advance the development of our research agenda without disclosing any single members’ proprietary activities.

For this purpose, I’d like to schedule a confidential conversation with you to discuss what you and a member (or more) of your research organization (if you have one) are currently focusing on (see attached sample questions).

We would also seek your suggestions or feedback about different strategies for collaborative research and information about your research suppliers that may be of value to other members.

This exploratory call requires no preparation, just a bit of your bandwidth and/or an introduction to others managing or performing research at your company. All information collected will be anonymized (not attributed to you or any AREA members)

Please click on this link to schedule a 30 minute (or less) call.”

APPENDIX 2

List of non-AREA member academics interviewed and a sample of their relevant projects:

[Steven K. Feiner \(PhD\) Professor of Computer Science and leads the Director of Computer Graphics, User Interfaces Lab at Columbia University,](#)

Sample Projects

- ParaFrustum: Visualization techniques for guiding a user to a constrained set of viewing positions and orientations
- Remote collaboration in AR and VR using virtual replicas
- Hands-free augmented reality for vascular intervention

[Rafael Radkowski, Assistant Professor of Mechanical Engineering, Department of Computer Science Iowa State University](#)

Sample projects

- Augmented Reality-Based Manual Assembly Support With Visual Features for Different Degrees of Difficulty
- Object Tracking With a Range Camera for Augmented Reality Assembly Assistance
- HoloLens Integration into a Multi-Kinect Tracking Environment

[Mark Billinghurst is Professor of Human Computer Interaction, School of Information Technology and Mathematical Sciences, University of South Australia](#)

Sample Projects

- Immersive Analytics: Interactive Data Analysis Using Surfaces and Spaces
- Enhancing human performance in complex environments
- Remote presence: a new approach for guidance on physical tasks