ROKE

INNOVATION THOUGHT LEADERSHIP

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EMPOWERING HUMAN ROBOT COLLABORATION FOR ENHANCED SITUATIONAL AWARENESS

This paper explores Roke's pioneering approach to Human-Robot Collaboration (HRC) and Augmented Reality (AR) for enhanced situational awareness and decision-making. By integrating advanced technologies like AR overlays and the Sensorium platform, Roke empowers tactical decision makers with real-time insights and optimised resource utilisation. The paper highlights the integration of UGVs, UAVs, and Boston Dynamics' Spot® into collaborative systems, showcasing the comprehensive capabilities of Roke's ecosystem. The challenges faced by previous AR implementations are addressed and the need to integrate enabling technologies and customise applications for maximum impact are emphasised.

Roke is committed to revolutionising situational awareness and decision-making by pioneering a holistic, human-centric integration of AR with complementary technologies and human elements, striving to create a safer, technologically empowered future.

CONTENTS

INTRODUCTION

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Technological advances continually reshape our understanding and interaction with the world around us, pushing the boundaries of human potential and capabilities. In the realm of Human-Robot Collaboration (HRC), a powerful synergy emerges when human intuition and machine precision join forces, leading to unprecedented enhancements in situational awareness and decision-making. This paper explores how Roke is pioneering innovations in HRC and augmented intelligence, leveraging cutting-edge technology, and integrating data from diverse sources to empower tactical decision-makers and maximise operational efficiency.

Augmented Reality (AR) forms an essential part of Roke's integration strategy, providing users with essential, actionable information overlaid on their real-world environment. The integration of human observations and machine-collected data leads to a comprehensive understanding of the situation and enhances situational awareness.

Roke's vision extends beyond individual tools to the development of an integrated ecosystem where humans, Autonomous Vehicles (AxVs), and autonomous digital agents collaborate seamlessly. Central to this vision is the Sensorium platform, an advanced amalgamation of command & control, geographic digital twins, supervision, visualisation, computing, communications, Artificial Intelligence (AI), AxVs and autonomous systems, integrating many different forms of technology. The transformation potential of HRC, facilitated by AR, AI, and platforms like Sensorium, becomes increasingly evident as Roke continues to expand technology integration, harnessing the power of AxVs and instantaneous communication between all elements within the HRC environment.

However, the promise of these technologies is not without challenges and many have tried integrating AR and HRC previously. Combining information within the visual and cognitive range of human senses and dealing with data privacy, cybersecurity, steep learning curves, compatibility issues, resistance to change, and regulatory obstacles all present hurdles that need to be surmounted. Despite these challenges, Roke's commitment to pioneering advancements in HRC and addressing these complexities is unwavering. This paper explores Roke's strategies, ongoing initiatives, and the transformative potential of HRC in enhancing situational awareness and rapid decision-making, showcasing the true power of contextually augmented intelligence.

CLASSIFICATION OF HRC

2

HRC encompasses various levels of interaction and collaboration between humans and robots.

- In coexistence HRC, humans and robots work independently in the same environment, performing separate tasks without directly affecting each other. For example, humans working alongside robots on a factory floor or monitoring robots in a control room.

- Coordinated HRC involves humans and robots working closely together, collaborating through physical interaction or shared tasks. This often includes collaborative robots operating alongside humans, such as humans and robots assembling products on an assembly line.

- In cooperative HRC, humans and robots actively contribute to the task, exchanging information, coordinating actions, and adapting to each other's inputs. Advanced sensing, communication, and planning capabilities are required. An example could be search and rescue robots collaborating with human responders in navigating a disaster-stricken area.

- Teaming HRC represents a deep integration of humans and robots as a cohesive team. Humans and robots have complementary roles, actively collaborating, making joint decisions, and executing coordinated actions. This level often involves autonomous robots and advanced AI systems, such as human-robot teams competing in joint tasks like robot soccer or aerial search missions.

These classifications provide a framework to understand the levels of interaction and collaboration in HRC. The choice of collaboration type depends on the task, safety considerations, capabilities of humans and robots, and desired integration and synergy. It is important to note that these classifications are not rigid, and real-world implementations can combine elements from multiple types, resulting in unique scenarios with their own characteristics. In this paper we focus towards Coordinated HRC.

EMPOWERING TACTICAL DECISION MAKERS & UNLOCKING AR

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At the heart of Roke's HRC approach lies CC1, a secure End User Device (EUD) built on Samsung's flagship Galaxy edition smartphone. Designed to provide unparalleled situational awareness at the tactical edge, CC1 combines commercial off-the-shelf (COTS) technology with a suite of Android apps that can operate in a secure controlled environment. By equipping tactical decision makers with this powerful tool, Roke empowers them with a battle-winning advantage, enabling precise control over the battlespace. This falls into the Coordinated HRC classification.

AR serves as a vital component in Roke's HRC strategy, overlaying critical information onto the real-world environment for individuals in the field. While AR provides invaluable insights, Roke recognises the importance of maintaining a balance between augmented views and the actual surroundings. With the aid of the display and the CC1 software features, the user has an alternative focus on the situational environment that helps to ensure that users remain grounded in reality, avoiding fixation on the augmented view, and leveraging the device's dynamic tasking capabilities. The integration of AR and the user's observations are combined in a way that allows the system to treat human observations as if they were data coming from a sensor. This approach enhances overall situational awareness by combining human insight with machine-collected data, ensuring a comprehensive understanding of the situation. This HRC values the human's observations and insights at the same level as the data the machine gathers.

EMPOWERING DECISION-MAKING THROUGH INTEGRATION

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Roke is building a HRC ecosystem and the Sensorium platform sits at the core of this strategy where we can explore HRC across all classifications.

The Sensorium is an advanced integration of visualisation, advanced computing and communications, artificial intelligence, machine learning, and autonomous systems. By amalgamating data from various sources and fostering collaboration between humans and robots, the Sensorium provides real-time situational awareness and a comprehensive understanding of complex environments. This revolutionary platform empowers users with accurate information and valuable insights, enabling informed choices and optimising operational efficiency.

UNLEASHING THE POWER OF SQUAD DYNAMICS

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Roke is actively exploring the development of a squad concept - a synergistic unit composed of Autonomous vehicles (AxVs), human operators, and autonomous digital agents. By incorporating both off-the-shelf and bespoke AxVs, Roke showcases the versatility and scalability inherent in the squad concept. The squad members, including AxVs and human personnel, harmoniously collaborate with the Sensorium to establish a dynamic ecosystem where diverse sensors and capabilities unite. This collaborative approach revolutionises surveillance by leveraging advanced algorithms and machine learning to reduce uncertainty and optimise decision-making. The capacity to augment the soldier's abilities and battlespace awareness is a critical aspect of these innovation efforts.

As Roke continues to incorporate a multitude of AxVs, thereby expanding the squad concept, the transformative potential of HRC becomes increasingly apparent. In contexts ranging from military operations to civilian applications, the seamless integration of humans and AxVs promises significant enhancements in situational awareness, facilitated by the fusion of human intuition and robot precision, as well as automation, and efficient information sharing enabled by instantaneous communication between squad members.

Moreover, this integration promotes operational effectiveness by leveraging the complementary capabilities of humans and AxVs. Harnessing the power of AxVs, AR, AI, and advanced platforms like the Sensorium, Roke is at the forefront of innovation, moulding the future landscape of humans collaborating with robots to enhance situational awareness and rapid decision making; this is contextually augmented intelligence.

AUGMENTED INTELLIGENCE

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Augmented intelligence is revolutionizing the way we interact with technology, transforming our capabilities, and addressing our limitations. A combination of AR, Virtual Reality (VR) and AI provides new avenues for enhancing our interaction with the world and expanding our cognitive abilities.

At Roke, we've been exploring the creation of digital twins for geographic locations using our ANAFI AI. These are overlaid within the Microsoft HoloLens 2 to integrate data from multiple sources, including AxVs, which helps us develop a comprehensive tactical picture. This information is also linked to the Sensorium, a platform that facilitates the fusion and interpretation of data. The ultimate aim is to simplify and focus our efforts, thereby promoting clear mission objectives. This is merely one of the many approaches we can take.

Our efforts aim to enhance situational awareness in a digital ops room and create a virtual collaborative environment. This allows experts to participate in table top discussions remotely, ensuring full immersion even when geographic co-location isn't possible.

An added advantage is the security provided by the HoloLens. If non-authorised individuals enter the room, any secure content remains invisible to them, a feature that monitor displays can't provide.

The headset's portability enables it to be used in military vehicles or on-the-go scenarios. It can be paired with a real physical table, eliminating the need for a computer or monitor, which in turn saves power. The AR headset is a see-through device, so users don't experience nausea. Users can maintain eye contact with others in the room and navigate the physical space, all while viewing the added overlay of digital content.

Here are some other examples of the applications possible and implications:

- Geospatial Navigation. AR enables location-based overlays, thus improving our ability to navigate our surroundings. Using AR, squads with humans in the loop can better coordinate and navigate in unison, enhancing overall operational efficiency.

- Security and Privacy. Target-based AR can securely 'hide' digital content, only revealing it when accessed via AR headsets or phone-based AR. This approach can ensure sensitive information remains secure while being accessible to authorized individuals, given the use of robust authentication methods like facial recognition, iris scanning, or voice recognition.

- AI and Content Refinement.   AI can enhance AR and VR experiences by curating the most relevant content, thus optimizing user experience. Additionally, Natural Language Processing (NLP) allows for human contribution and collaboration, fostering a more interactive environment.

- Electromagnetic Spectrum Analysis.   AR has the potential to superimpose EW and radio frequencies onto the real world, providing users with a vital informational advantage and enhancing decision-making.

- Spatial Analysis.   AR, coupled with distributed intelligence, allows for better visualization of ISR assets, enhancing situational understanding and decision-making capabilities.

- Disaster Management. In emergency situations, AR can provide real-time visualizations of disaster scenarios, improving decision-making, resource allocation, and coordination among response teams.

Augmented intelligence can enable a shift in how we perceive and interact with our environment. AR, VR, XR, and AI not only augment our sensory and cognitive abilities but also empower us to make more informed decisions. Embracing these technologies allows us to harness their potential while adhering to ethical standards.

Advancements in VR, including multi-sensory stimulation and the integration of haptic feedback, allow for more immersive experiences. When AR is combined with VR, users receive real-time information and guidance, which enhances their decision-making abilities and overall performance. The convergence of AI and AR/VR also paves the way for adaptive interfaces that learn from user interactions, continually improving and personalising the user experience. This vision of augmented intelligence underscores a future where technology, responsibly deployed, can indeed become a powerful ally of human potential.
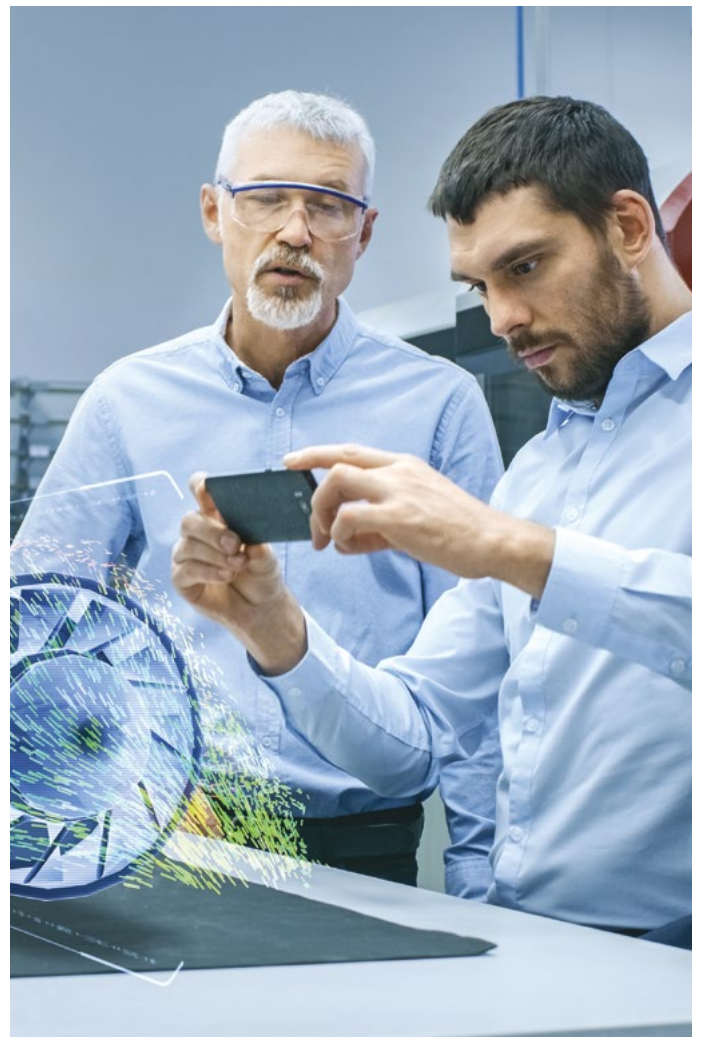
ENHANCING SITUATIONAL AWARENESS

7

In high-stress environments like military operations and emergency response scenarios, AR and VR technologies can revolutionise situational awareness, navigation, and training. AR assists in navigation by revealing routes, hazards, and team member locations, even in challenging visibility conditions. It enhances overall situational awareness, potentially saving lives and these technologies, combined with smart sensor data and detailed urban mapping provided through digital twins, can guide individuals through safe routes, providing real-time information on air quality, topography, and potential hazards. This improves safety and minimises risks, especially in environments with invisible post-explosive hazards.

AR's ability to visualise geospatial points of interest over the real world is invaluable for Dismounted Situational Awareness in military operations. Ongoing advancements in registration accuracy further enhance the precision and effectiveness of AR systems. To address GPS-denied areas, Roke is developing a GPS-independent location system based on Integrated Visual Navigation System and Robust Position Navigation and Timing services. This innovative solution ensures accurate location information for AR and machine vision technologies, even without GPS signals.

In the realm of VR, the focus shifts to supporting complex data visualisation and immersive training applications. VR training simulates life-threatening situations, offering a collective experience for personnel to analyse and develop skills in a controlled environment. Realistic scenarios with water, smoke, and fire effects can be replicated with high fidelity, providing practical training experiences that would be impractical and costly in the real world.

TECHNOLOGY CHALLENGES

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In a period marked by the rapid convergence of technologies for enhanced situational awareness in HRC, it is clear that we stand at the threshold of transformative potential. Yet, as we integrate emerging technologies such as AR with autonomous and semi-autonomous entities, like CC1 and squad members within the Sensorium's command environment, we also grapple with various challenges that accompany implementation.

Key considerations include data privacy and cybersecurity, as these technologies depend on processing classified or secure data, warranting robust safeguards against unauthorized access and cyber threats. Training demands for AR and VR technologies also pose hurdles due to their resource-intensiveness and steep learning curves, despite their potential to streamline operations once mastered and reduce operational burdens.

Various barriers obstruct the adoption of HRC, AR, and VR technologies, including cost, compatibility with existing infrastructure, resistance to change, and regulatory challenges. Addressing these obstacles demands collective action involving technology providers, policymakers, and end-users.

Notwithstanding the potential security risks, innovative biometric authentication methods and multi-layered security strategies have been suggested to secure access to these technologies. Despite the current challenges, ongoing advancements in AR technology and security measures are promising.

Seamless communication, a crucial component of HRC, presents its own hurdles in terms of latency, bandwidth, and connectivity. This necessitates the development of robust communication protocols and technologies, such as edge computing and low-latency networks.

Additionally, the dependence of AR and VR technologies on computing power brings to light the challenges of battery life and computational capabilities. Balancing high-performance computing with energy efficiency is essential, pointing towards future advancements in battery technology, energy management systems, and edge computing.

Finally, the physical burden of devices and equipment in HRC applications demands lightweight materials, component miniaturisation, and ergonomic design to ensure user comfort and performance.

While the convergence of HRC, AR, and other technologies ushers in a promising era of enhanced situational awareness and decision-making, it is crucial to recognise and tackle these complex challenges. As Roke continues to pioneer advancements, we remain dedicated to addressing these issues, working towards cost-effective, compatible, and secure solutions while continually engaging stakeholders to refine and improve capabilities.

ROKE'S VISION

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Roke is committed to pushing the boundaries of HRC across the different types of HRC classifications, leveraging cutting-edge technologies, and adopting a holistic approach to empower tactical decision-makers and maximise operational efficiency in complex environments.   This is being addressed by:

- Empowering Tactical Decision makers & Unlocking AR through the fusion of human insight with machine-collected data enhances overall situational understanding.

- Empowering decision-making through integration by developing a HRC ecosystem, amalgamating data from various sources for real-time situational awareness.

- Unleashing the power of squad dynamics by exploring a squad concept comprising autonomous vehicles, human operators, and autonomous digital agents for collaborative surveillance.

- Augmenting human intelligence by combining AR, VR, and AI to provide transformative applications ranging from geospatial navigation to national security.

- Researching technology challenges, including data privacy and cybersecurity concerns, steep learning curves for training, adoption barriers, and hardware limitations to develop cost-effective, compatible, and secure solutions.

CONCLUSION

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Roke's innovative efforts in the field of HRC are potentially leading the way in which we perceive and interact with our environment. Whilst this paper is largely looking at enhanced situational awareness through combining digital agents with AR, this is just one element being explored. By seamlessly merging the physical and digital realms through tools such as CC1, AR overlays, digital twins and the Sensorium platform, it is possible to providing tactical decision-makers with unparalleled insights and control. The culmination of these technologies not only enhances operational efficiency and intelligence analysis, but also facilitates a novel level of human-robot synergy. As squads - the integrated units of autonomous vehicles, human operators, and autonomous digital agents - become more widespread, the true potential of all forms of HRC will continue to unfold.

A commitment to advancing HRC and AR through ongoing research and development initiatives will push the boundaries of what is possible by integrating autonomous vehicles, expanding the capabilities of the Sensorium platform, and fostering greater collaboration between humans and robots. This convergence of Virtual Reality, Augmented Reality, Extended Reality, and Artificial Intelligence is not merely transforming the way we interact with our surroundings, but it's also empowering humans to thrive in an increasingly augmented and intelligent environment.

However, the road to this future is not without its challenges. Concerns regarding data privacy, cybersecurity, technological learning curves, and issues surrounding adoption, cost, and compatibility with existing infrastructures are all part of the journey. The path to future success is to face these challenges head-on, adhering to responsible implementation practices to ensure that the benefits of these technologies are harnessed for the betterment of humanity.

Looking towards the future, envisions the widespread application of squads with integrated HRC capabilities across a multitude of sectors, including but not limited to defence, security, agriculture, healthcare, and emergency response.

The potential applications are vast, ranging from remote surveillance and disaster management to critical infrastructure protection. Even industries not yet considered are likely to benefit from the integration of these technologies. Through a blend of collaboration, innovation, and responsible practices, Roke is paving the way for a future where advanced technologies serve to empower individuals and societies alike.

CALL TO ACTION

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Roke invites industry leaders and innovators to join forces with Roke in shaping the future of HRC. Together, we can overcome real-world challenges and develop ground-breaking technologies that revolutionise situational awareness and decision-making.   Let us harness the power of collaboration to unlock the full potential of HRC, and advanced technologies, driving advancements in many diverse sectors. By working together, we can create a safer and more technologically empowered world. Join us on this transformative journey and be at the forefront of shaping the next generation of AR solutions.

We believe in improving the world through innovation. We do it by bringing the physical and digital together in ways that revolutionise industries.

That's why we've fostered an environment where some of the world's finest minds have the freedom, support and trust to succeed.

Roke is a team of curious and deeply technical engineers dedicated to safely unlocking the economic and societal potential of connected real-world assets. Our 60 year heritage and deep knowledge in sensors, communications, cyber and AI means our people are uniquely placed to combine and apply these technologies in ways that keep people safe whilst unlocking value. For our clients, we're a trusted partner that welcomes any problem confident that our consulting, research, innovation and product development will help them revolutionise and improve their world.

If you're bringing the physical and digital worlds together, we'd love to talk.

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