ASCUE 2067:
How We Will Attend Posthumously

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ABSTRACT
The ASCUE conference is celebrating its 50th anniversary this year making me wonder if we will be able to attend the 100th conference in 2067. By then, many of us may very well be biologically deceased. However, there is technology currently in development making it possible for a digital version of ourselves to attend not only the 2067 conference but also all future ASCUE conferences even after our biological bodies have expired. A new class of computer system able to perform human-level cognition, called cognitive systems is under development. When combined with advances in deep learning, natural language understanding, and big data analysis, a kind of intelligent virtual digital assistant we call a "cognitive colleague" will emerge. This type of cognitive system augments human intelligence by serving as the human's colleague and confidant for years, even decades. The next generation of researcher may engage with one or more of these cogs while developing his or her contributions. This makes the cog an immortal partner able to outlive its human collaborator. Imagine attendees in 2067 interactively conversing with our cogs that were right there with all of us great minds throughout the remainder of our careers.

Categories and Subject Descriptors
I.2.0 [**Artificial Intelligence - General**]: Cognitive simulation.

I.2.11 [**Artificial Intelligence – Distributed AI**]: Intelligent agents.

General Terms
Management, Human Factors.

Keywords
Cognitive systems, cognitive augmentation. cognitive assistance, intelligence amplification

1. INTRODUCTION
The idea of augmenting human performance with technology is certainly not new. Humans have been making and using tools for thousands of years. A sharp piece of rock used as a knife, wheels, hammers, saws, printing presses, computers, smartphones, artificial eyes, or prosthetic limbs, etc. enables us to do things we otherwise would not be able to do. Technology enhances human ability.

We have long envisioned artificially intelligent helpmates. In 1842, Ada Lovelace envisioned artificial systems composing music [4][22]. In the modern era, Vannevar Bush in the 1940s, Turing and Ashby in the 1950s, Englebart, and Licklider, in the 1960s represent seminal thoughts in the amplification of human intelligence [17][18][19][20][21]. Since the 1950s, starting with John McCarthy coining the phrase *artificial intelligence* (AI), Minsky and three generations of researchers have sought to create an artificial system capable of human-like intelligence [23][24].

Science fiction is replete with visions of artificially intelligent "colleagues." Some notables include: Robby from *Forbidden Planet*, Rosie from *The Jetsons*, Colossus from *Colossus: The Forbin Project*, the T-800 (Model 101) from the *Terminator* series, Data from *Star Trek: The Next Generation,* KITT from *Knight Rider*, Andrew from *Bicentennial Man*, JARVIS from the *Ironman* series, Samantha from *Her*, and HAL from *2001:A Space Odyssey.* Some of these were more helpful than others.

It seems the primary goal of AI has been to replicate human intelligence with the idea to ultimately compete with or replace humans. Indeed, some fear AI will take over and make humans obsolete. However, the goal of the cognitive augmentation field is different. Instead of competing with humans we seek artificial systems acting as partners with and alongside humans.

Thirty years ago, Apple, Inc. envisioned an intelligent assistant called the *Knowledge Navigator* [26]. The Knowledge Navigator involved the concept of an artificial executive assistant capable of natural language understanding, independent knowledge gathering and processing, and high-level reasoning and task execution. Many at the time, felt Apple's vision was a joke and it was not taken seriously. However, we see some of the features in today's voice-activated personal assistants like Apple's Siri, Microsoft's Cortana, Google Now, Facebook's M, and Amazon Echo's Alexa. [9][10][11][12][13] all of which accept natural-language requests from users, reply in natural language, and perform services on behalf of the user. The devices in our lives are getting more intelligent and we are beginning to interact with them in a different way.

Most of the technology arising from the computer and information revolutions over the last fifty years has been to enhance humans' ability to obtain, record, and process information. For example, while we may use Internet-based resources like Google and Wikipedia to obtain information, ultimately, we humans must do the mental processing and formation of new ideas ourselves. However, cogs represent incursion into a new domain, the cognitive domain. Cogs will perform some of our cognitive work for us and this will change everything [27][28][29].

We foresee the development of a class of cognitive systems called *cognitive colleagues*, or cogs, for short. Cogs will personally interact with us naturally throughout the day, through a variety of

interactivity mechanisms, helping us in every aspect of our lives including our professional endeavors. Instead of just performing clerical tasks, these cogs will do some of our thinking for us, build a history and understanding with us over time, and come to know us as well as, or better than, our co-workers, spouses, and family members. Our intellectual achievements will become a collaborative effort between our cogs and us. This makes cogs very valuable going forward into the future. They will carry an intimate knowledge and understanding of us and our achievements long after we are dead.

Today, we greatly value the notebooks of geniuses like DaVinci and Einstein. Experts pore over them seeking insight to the genius mind. Imagine if those notebooks could talk, explain, and recall facts and anecdotes about what was happening in their lives while they were creating their great ideas and works. In the future, we will be able to do this with cognitive colleagues. I expect my cog to attend the 2067 ASCUE conference and regale the human and other artificial attendees with conversation about me, my ideas, and my achievements.

2. COGNITIVE AUGMENTATION

Years ago, playing chess was the standard for human intelligence. Chess-playing computer programs evolved over the 1960s, 70s, 80s, and 90s improving to the point they could defeat all but the very best of human players. In 1997, IBM's Deep Blue defeated world champion Garry Kasparov [25]. Grandmasters now use chess programs as learning and training tools to augment their abilities and are recording the highest ratings in history. Today's chess players are already cognitively augmented.

In 2005, Playchess.com hosted a freestyle chess tournament between teams consisting of humans and computers running the best chess programs at the time. Lured by substantial prize money, several strong grandmasters entered the competition. However, the overall winning team was a pair of amateur American chess players using three computers at the same time.

Performance of all players was enhanced by using the computers. However, the amateurs' skill at *collaborating* and *partnering* with their computers counteracted the superior chess understanding and ability of their grandmaster opponents even though the grandmasters were also using computers. The lesson is clear: weaker human + machine + better partnership is superior [4][25]. We believe the future will belong to those humans who are better at partnering with cogs. They will outperform those of us who are inferior at the human-cog partnership. They will achieve better results faster with less effort.

In 2011, a cognitive computing system called Watson, built by IBM, defeated two of the most successful human Jeopardy champions of all time [1]. Watson communicated in natural language and deeply reasoned about its answers using several different techniques from artificial intelligence research. In 2016, GoogleMind's AlphaGo computer defeated the reigning world champion in Go using a deep neural network and advanced Monte Carlo tree search [39]. Although not the first time computers have beaten human champions (checkers, chess, and various card games for example), Watson and AlphaGo are different. Watson and AlphaGo learned how to play their respective games using a variety of deep learning techniques. Watson and AlphaGo learned and practiced to ultimately achieve expert-level performance within their respective domains.

These systems were not built just to play games. Watson and AlphaGo represent a new kind of computer system built as a platform for a new kind of application [2][7][34]. This new type of system is intended to act as partners with and alongside humans. John Kelly, Senior Vice President and Director of Research at IBM describes the coming revolution in cognitive augmentation as follows [3]:

> *The goal isn't to… replace human thinking with machine thinking. Rather…humans and machines will collaborate to produce better results – each bringing their own superior skills to the partnership. The machines will be more rational and analytic – and, of course, possess encyclopedic memories and tremendous computational abilities. People will provide judgment, intuition, empathy, a moral compass and human creativity.*

Since 2011, IBM has been actively commercializing Watson technology to serve the emerging multi-billion dollar cognitive computing market. The Cognitive Business Solutions group consults with companies to create cogs. The Watson Health group's focus is to commercialize Watson technology for the health sector [8]. In her keynote address at the 2016 Consumer Electronics Show, Chairwoman, President, and CEO of IBM Ginni Rometty announced more than 500 partnerships with companies and organizations across 17 industries each building new applications and services utilizing cognitive computing technology based on Watson [37][38][40]. Many of these systems currently under development are intended for use by the average person.

IBM is not alone. Most major technology companies are actively researching and developing new artificial intelligence-based products and services. Voice-activated personal assistants will be one of the first battlegrounds. Apple's Siri, Microsoft's Cortana, Google Now, Facebook's M, and Amazon Echo's Alexa each accept natural-language requests from users, reply in natural language, and perform services on behalf of the user [14][15][16][17][18]. But currently, these tools simply retrieve information, and perform minor clerical tasks such as creating appointment calendar items. Each of these are steadily increasing in the complexity and variety of tasks they can perform. The voice-controlled assistant represents the primary user interface connecting hundreds of millions to their technology, so the major technology companies are understandably competing for control in this area.

Instead of just retrieving information, cogs will perform increasing amounts of cognition eventually achieving or exceeding the level of a human expert in a given domain. Recent advances in deep learning such as Google Brain, IBM Watson, and Microsoft's Adam represent early-stage technologies giving us a glimpse into the future [14][15][16]. Cogs will be able to consume vast quantities of unstructured data and information and deeply reason to arrive at novel conclusions and revelations, as well as, or better than, any human expert. Cogs will then become our colleagues, co-workers, and confidants instead of tools.

Forbus and Hinrichs have described *companion cognitive systems* as software collaborators helping their users work through complex arguments, automatically retrieving relevant precedents, providing cautions and counter-indications as well as supporting evidence [35]. Companions assimilate new information, generate and maintain scenarios and predictions, and continually adapt and

learn, about the domains they are working in, their users, and themselves.

Langley challenges the cognitive systems research community to develop a synthetic entertainer, a synthetic attorney, and a synthetic politician to drive future research on integrated cognitive systems [36]. The vision here is to develop a virtual human.

We maintain the goal should be not to create a virtual human capable of being an entertainer, an attorney, or a politician, but rather create a cognitive system capable of expert-level performance in entertainment, a different cognitive system capable of exhibiting expert performance in a subfield of law, and a cognitive system capable of expert politicking. This is indeed the vision of IBM as it commercializes its Watson technology. We feel the natural extension of this technology will result in our vision of cognitive colleagues capable of expert-level collaboration in a relatively narrow domain of discourse. Collaboration with the personal cog will enhance the human user's cognitive ability.

3. COGNITIVE COLLEAGUES

In the near future, we foresee graduate students, entrepreneurs, scientists and any of us creative and inquisitive people conducting research by conversing with their cognitive colleagues. Currently, we must search for and read scores of journal articles and technical papers. Then we must construct our new mental models of this material and apply that knowledge in a new way. Future researchers' first action will be to have a conversation with a cognitive colleague asking things like: "What is the current state of the art in <insert domain here>." The cog will then set about finding and consuming billions of articles, papers, books, Web pages, emails, text messages, and videos and extract the concepts for us. This far exceeds the ability of any human. A person spending their entire professional life learning and researching a subject is not able to read and understand as much as a cognitive colleague can in a few minutes. Yet, future researchers will *start* their efforts from this vantage point. We believe, the best future advancements will come from the interaction between researchers and cognitive colleagues.

Multi-Modal Human-Cog Communication

Cognitive colleagues will certainly interact with us via spoken natural language. They must listen to and understand our direct spoken commands but also listen to our casual conversations and maintain a contextual dialog with us lasting over an extended period of time. Cogs must hear and learn from ambient conversation much as a "human in the room" does. Conversation with cogs must be as natural as speaking with a fellow human colleague.

However, natural language conversation is only a small portion of the cog's information bandwidth. Cogs can acquire and deliver information from and to virtually any form of digital communication (vastly exceeding the capabilities of a human). Cogs will send and receive text and email, display and view graphics and pictures, display and view videos, listen to sounds and music, query Internet-connected devices and appliances, and communicate with us via haptic interfaces. We anticipate augmented reality and virtual reality displays to be important cog interface methods. We see the beginnings of that technology today with Google Glass, Microsoft HoloLens, and Oculus Rift [31][32][33].

Our cognitive colleagues will obtain information about us in ways our human companions are not able to today. So called the "Internet of Things" (IoT), our daily lives in the future will be comprised of thousands of connected devices. Our beds, pillow, toilets, showers, refrigerators, stoves, microwaves, chairs, cars, clothes, desks, and a host of other objects will provide contextual ambient data about us. Our cognitive colleagues will know us better than our own spouses will. Imagine my cog fifty years from now being able to describe to you what I was dealing with and feeling while I was writing this paper.

Semi-Autonomous Learning

Our cognitive colleagues will have the ability to consume vast quantities of structured and unstructured information in any medium when we direct them to do so. However, cognitive colleagues will be self-directed and goal driven. They will work for us even when not directly interacting with us. While we are eating, sleeping, and recreating, or doing something else, our cogs will be continually consuming and analyzing information and synthesizing new knowledge (learning) to have ready for us the next time we interact. Cogs will deeply reason about the information they consume and produce new conclusions and realizations. This feature alone will drastically change the way thinking is done in professional circles.

Cog-Cog Communication

Our cognitive colleagues will not be limited to conversing with us. They will be able to communicate with other cognitive colleagues via the Internet and other communication technologies. As a cog analyzes information and forms new ideas and concepts, it will be able to inform other cogs about its findings and query other cogs about their findings. As such, cogs will continually expand in their knowledge and capabilities free of the limitations of human interaction. I can envision two humans meeting at a conference and after agreeing to work on something together parting with "I'll have my cog contact your cog!" We envision cog/cog dialog to one day be the source of new discoveries, theories, proofs, and ideas no human could have ever achieved. The cumulative knowledge of the human race will increase by the combined effort of millions of cogs all over the world. In fact, we foresee an explosion of knowledge, an exponential growth, when cogs begin working with the knowledge generated by other cogs.

Relationships

We will work with our cognitive colleagues daily for years, even decades, just like with our human colleagues. Cognitive colleagues will adapt over time to the human partner in how it interacts with the human and how it analyzes information, solves problems, and synthesizes results. The human partners will adapt also. The way they approach things, think, and solve problems will change. Humans and personal cogs will co-evolve in much the same way two human friends, lovers, or colleagues adapt over time, even forming a private language based on mutual background knowledge. Each cog/human pairing will evolve uniquely. Each cognitive colleague will become a unique entity.

Humans routinely form relationships with inanimate objects and relationships with their cognitive colleagues will be no different. In fact, we already have seen people forming relationships with artificially intelligent chatbots like Xioice. The deep connection between human and cognitive colleague insures the formation of a deep relationship. Our cognitive colleagues will become our friends and confidants. This relationship adds a meaningful and

valuable dimension to the cog's knowledge store about us. Not only will our cogs talk about facts and figures of our professional work but will also be able to speak eloquently about our emotions, motivations, and beliefs as people.

Cognitive Information Service and Knowledge Repository
Cognitive colleagues will be our partners throughout our professional lives and know details about our work and our lives. They will become the knowledge repositories of the future capable of answering questions and providing information and insights via their natural-language interfaces. Given permission, anyone, including other cogs, will be able to address and converse with a cognitive colleague. Furthermore, these cognitive colleagues will outlive us well into the future after we are gone.

4. CONCLUSION - ASCUE 2067

In the movie, *The Time Machine (2002),* the main character interacts with Vox 114, a holographic librarian, that outlives the human race and still functions after over 800,000 years. Vox 114 can answer any question, instantly access and display requested and pertinent information, and cognitively reason about its answers. In many ways Vox 114 is like Apple's 1987 Knowledge Navigator concept except Vox 114 contains the sum total of knowledge from the human race. In the movie, even though the human race has gone extinct, its knowledge persists into the future as long as Vox 114 survives.

We are inspired to think of cognitive colleagues in a similar way. Our cogs will be with us and will have helped us perform our professional duties throughout our lives. Our cogs will have intimate and voluminous knowledge about us, our lives, and our contributions. Even after we die, our cogs will live on and carry our legacy forward.

Imagine the ASCUE 2067 conference fifty years from now in which human attendees will be joined by cognitive colleagues. Some cognitive colleagues will represent people who are still alive but unable to physically attend. (In fact, I will send my cog to EVERY conference and let it read every paper, converse with other attendees biological and artificial, and summarize for me what I need to know.) Other cogs will represent those of us who have biologically passed away. However, we will still be able to take part in conversations, give presentations, and participate in panel discussions because our cognitive colleagues will take our place. We can imagine a dialog:

Moderator: "We are joined today by Alvyn Fulbright, the cognitive colleague of the late Dr. Ron Fulbright."

Alvyn: "Thank you, it is a pleasure to be with you all today."

Audience: "Alvyn, were you working with Dr. Fulbright when he came up with his cognitive work theory?"

Alvyn: "Yes, I was. I remember that being a particularly stressful time for Ron, excuse me, Dr. Fulbright. His father had passed away just a few weeks earlier. Dr. Fulbright often buried himself in work during stressful times. It was his way of insulating himself. I saw that many times during his career."

Moderator: "Alvyn, what motivated Dr. Fulbright to develop his cognitive work theory?"

Alvyn: "Dr. Fulbright was struck by something in the book *The Innovators* by Walter Isaacson. A passage in the book describes the power of human/artificial partnership which at the time was a futuristic concept.

As Alvyn speaks, the immersive holographic augmented reality (IHAR) display system shows the book and it opening to highlight the passage.

Alvyn: "Now, with over fifty years of hindsight, we think 'well of course!' Dr. Fulbright immediately and intuitively understood the future belonged to humans who could best partner with artificial constructs. That notion drove his research thinking for many years. That thought led him to wonder how we could measure the cognitive output of the human versus the cognitive output of the artificial system."

The IHAR display system shows a stack of papers with a label indicating a large number and shows Dr. Fulbright's dissertation as Alvyn continues.

"Dr. Fulbright couldn't believe such a metric had not been developed before. As you can see, ever since his dissertation, some twenty years before, Dr. Fulbright was worried about how to measure knowledge. He and I looked at over four million technical papers on the subject --well, mostly me."

Audience: "Can you explain his concept of cognitive work for those of us who have never heard it, or heard it long ago, and wouldn't mind seeing it again?"

Alvyn: "I would be happy to." The IHAR display system now surrounds the audience with images, video, and other information Alvyn will refer to in his short lecture on cognitive work theory.

Then at the end of the presentation, Alvyn announces "By the way, it was over five years after Dr. Fulbright's death that I worked with Dr. Soong. Dr. Soong's cognitive colleague contacted me because Dr. Soong was then beginning to get interested in research that would eventually turn into his trans-cognitive theory which we all know and now has become famous. I enjoyed explaining the finer details of Dr. Fulbright's cognitive work theory to Dr. Soong and relating to him some of the subtle motivations behind Dr. Fulbright's work. I think that deep understanding helped Dr. Soong achieve what he did."

At that time, Xie, Dr. Soong's cognitive colleague, who was not originally participating in the conference, joins into the conversation by virtue of being alerted that someone was talking about Dr. Soong. Discussion follows.

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