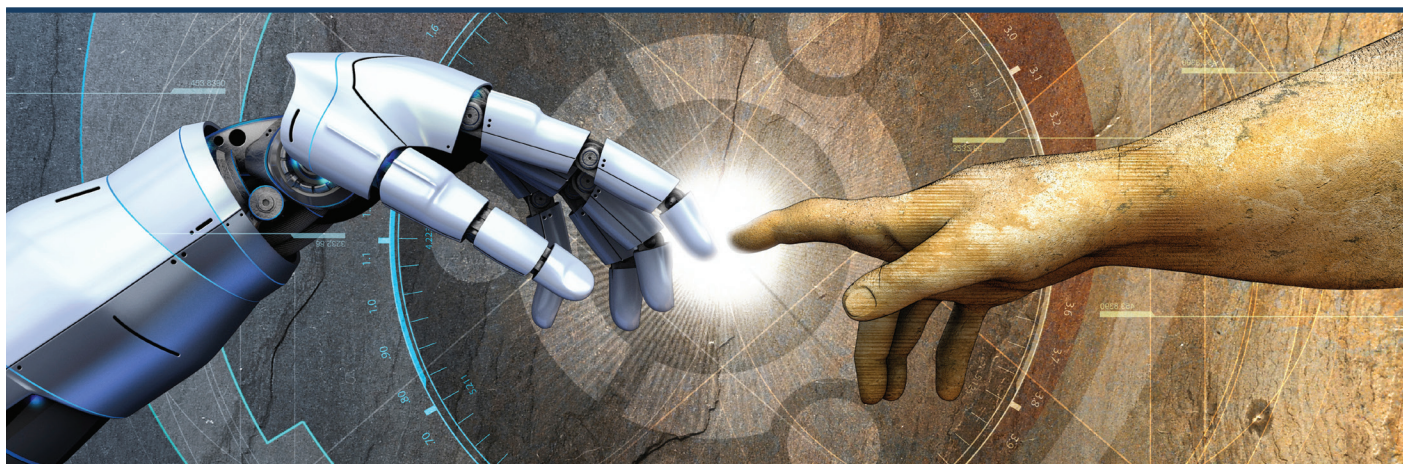


SPECIAL REPORT: Evolution at the Crossroads of Technology

AMG 
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What's the next big thing? The next innovation that will captivate consumers, spawn new industries, create wealth and ultimately change society?

Where are these disruptive, transformative technologies? Who is developing them? And when will they be ready for market? Savvy investors, from big-time venture capitalists to small-time stock speculators, are constantly asking those questions, searching for answers and opportunities.

Artificial computer intelligence, AI for short, seems poised to be that next big thing.

AI is the latest step in the evolution of computers, where increasing smart and sophisticated machines are capable of analyzing information and making decisions independently of humans. Many see it as a blossoming field ripe for developing a myriad of technologies each with the potential to disrupt existing economic paradigms and transform society as we know it over the next five to 50 years and beyond.

AMG brought AI and its investment potential to the attention of about 250 clients and others at a special autumn event titled *"Evolution at the Crossroads of Technology."* The event featured Apple Computer co-founder Steve Wozniak and venture capitalist Brad Feld, co-founder of Boulder-based Foundry Group, who both shared their insights into the future of computers and artificial intelligence.



Steve Wozniak
Co-founder of
Apple Computer



Brad Feld
Co-founder of
Foundry Group

SEEING THE FUTURE

Spotting the next big thing isn't easy because technology today is evolving on an exponential scale. Feld likened it to a geometric curve, adding that many breakthroughs happen by pure chance, or by combining two or more previously unrelated technologies.

"I think one of the real challenges for humans is understanding what transformative [technology] is," he said. "A lot of things happen by accident, not by planning. One of the phenomenal challenges for humans to understand is the geometric curve. We think about everything in terms of a line. We are moving on a line until we hit a point where it changes at an incredibly rapid rate."

"When we think about the next transformational thing ... we actually create the transformational thing by combining things in an unexpected way. There are many things happening that we cannot see until we actually reflect by looking back."



The next big thing could start out simply as a child's toy.

AMG supplied one to illustrate his point. It is a robotic ball called the Sphero BB-8 and is based on a character from the new Star Wars movie. The \$150 toy stands 4.5 inches tall and can travel up to 100 feet. The toy is controlled by a smartphone app and has AI learning abilities that allow it to learn from its environment, adapt to user preferences and react to voice commands with a range of expressions. Feld's Foundry Group, which boasts previous successful investments such as Fitbit health trackers and MakerBot 3D printing, is currently invested in Sphero and its AI technology.

"When we look at an investment," Feld said, "we think how cool and difficult would it be to create it."

Where the Sphero technology goes in the future is promising. Humans are rapidly creating AI-enabled devices and beginning to rely on them. Think of Siri on an iPhone.

"We get comfortable with the notion of interacting with robots as a result of engaging with them, and talking to them," Feld said. "All of a sudden it becomes a reality."

Feld and Wozniak see AI creating many new realities and transforming society in many ways. They gave several examples:

THE NEXT BIG THINGS

Voice Recognition: Wozniak believes the next transformational technology is here now in the form of computers becoming increasingly smaller and easier to use. He points to the smartphone and the Siri voice-recognition software as the latest evidence of this trend.

"I think voice recognition is getting better and better," Wozniak said, calling it an incredibly important innovation because it makes computer use as easy as talking.

Feld pointed out voice-recognition technology has been around since the 1970s but only has become a popular consumer product since Apple introduced Siri in 2010. It is a reminder of how once obscure technological innovations can sit dormant for decades before society realizes their utility.

"Remember how the computers were before Mac?" Wozniak asked. "You had to memorize the commands to tap into the computers. Now it is more human. Every step of the way computers have become more human themselves. Think about the politeness factor, obedience factor and reliability. Now you are forgetting about all the structural things and start speaking to your phones."

Self-Driving Automobiles: Wozniak predicted the next big thing five to 10 years from now will be the "assisted-driving car," where a smart computer drives for you, scanning the road with cameras, reacting to other drivers and even anticipating and avoiding problems. Google has been testing prototype autos in California, and Tesla Motors has begun selling software that allows its electric cars to go driverless.

"Self-driving cars are the biggest (AI) innovation of all in economic terms," Wozniak said. Every major auto manufacturer will offer assisted-driving car options, which will dramatically cut accident rates because computers don't miss stop signs or drive impaired, he predicted.

"What's going to happen to our lives when we have 1/20th as many accidents?" he wondered. "Are they even going to allow humans to drive cars?"



Human Augmentation: Looking 20 years into the future, Feld expects “human augmentation” to become a big thing. Right now, there are contact lenses and hearing implants, corrective vision surgeries, joint replacements and articulating artificial limbs.

“This sort of physical augmentation is something we’re already pretty used to,” he said, noting that it’s not too far-fetched to consider eventually connecting your brain directly to the Internet.

“What is happening now is the boundary between the human and the technology is starting to blur,” Feld said, predicting that there will be a number of advances in biological computing in coming years. Fitbit, the health-monitoring device people wear on their wrists, is just the beginning of this field, he said.

Wozniak speculated that eventually we might be able to create implants for eyes and ears, and robotic limbs that are better than what nature gave us. Feld joked about the “golf augmentation” that allows everyday hackers to know the exact distance to the pin for any lie on the course.

Education: Despite the computer’s impact throughout society, Wozniak said, education has yet to see its next-big-thing revolution. The problem is kids now are taught “not to be creative, not to think differently from everyone else, the right answer that gets you called intelligent is the same answer as everyone else and it came usually from a book and not from your own thinking.”

The reason for it, Wozniak continued, is one teacher has to teach 30 students and keep control. There isn’t a lot of individual attention, he said, and kids often fall in love with a subject – whether its mathematics, drama or literature – at an early age and aren’t allowed to pursue it as deeply or as fast as they want because they have to study for tests on five other subjects.

The solution is AI, he said, creating a conscious or sentient computer that can tailor a personal curriculum for each student and then guide that child’s learning experience at an appropriate pace.

“What if a machine looked at me and knew me and cared about me ... knew what subjects I wanted learn, and what I wanted to do?” Wozniak wondered. “One teacher per student can never fail a student if it cares.

“Maybe when we have that kind of machine, education can change.”

Society needs to do a better job of enticing girls and women to study computer science, Feld contended.

“The gender dynamic in computer science is one of the depressing parts of our culture, which is 80% male and 20% female,” he said, noting that the ratio has started to decline in the past 12 months in some parts of United States.

“Learning how to interact with computers and speaking computer language is now more important than learning foreign languages.”

The secret to educational success, he said, remains parents’ engagement with their children in their studies “by actually doing projects together.”

Economic Efficiency: Businesses will continue to look to technology for competitive advantages in the form of faster speeds and better efficiency. Businesses that recognize the next big thing generally profit; those that don’t fade into history.

“Machines are getting smarter and smarter and taking over for humans,” Wozniak said. “In the financial industry, 80% of trades are from computer to computer. It is economics, and you cannot put a slow broker in the middle.”

The trend of machines performing jobs better and faster than humans will accelerate as AI advances and evolves in coming decades, Feld and Wozniak agreed. That raises interesting ethical questions.

“What if machines could think so much faster than humans do, and what if machine CEOs do much better than human CEOs?” Wozniak asked.



ETHICS OF ARTIFICIAL INTELLIGENCE

Computers today don't yet have a human CEO's intuition and ability to organize and solve problems, Wozniak said, but they now can pay attention, think and do nearly everything else humans can do intellectually.

"So what happens when computers get truly intelligent and start doing the same things much faster than humans can do?" he asked. "Are the robots going to start taking on the jobs of people? What if the robots come to a point that they start teaching themselves how to do things faster than humans do?"



Feld argues that society is lagging behind technology in terms of regulatory and ethical considerations.

"We are still in a place now where humans try to control the technology even though the technology is well beyond where we can control it," he said, citing the Uber example.

Uber is a phone application that allows users to summon within minutes a car and driver, who is an independent contractor, and pay online for the ride. The service, which began in 2009, undercut taxi companies, which were heavily regulated by government bodies that were unprepared for the advent of the Uber business model, which only now is starting to be regulated.

"Simply our legal systems and laws cannot curve up with the level of information anymore," Feld said. "The regulations create enormous societal stress ... the technology is expanding so much faster than the regulatory environment."

Society faces enormous ethical and regulatory challenges in the future, especially in the field of biomedical computing.

"The notion of human augmentation is going to be really complicated," he said. "Think what happens if we get augmented?"

Who can get augmentations that improve human performance? Will certain enhancements even be allowed? If they are, will they be available to everyone or just those that can afford them or need them? Who will decide who needs them?

Feld contends that each of us must decide whether he or she has a cynical or optimistic view of AI and its future in society.

"Computers can take over the world: This is the pessimistic view," Wozniak said, noting a concept called "singularity," which is the point where smart machines create intelligence far exceeding human intellectual capacity or control."

One of the challenges is whether humans use technology to make life better on this planet over the next 50 years, Feld postulated, or will technology displace humans from controlling their own destiny.

That's perhaps the biggest next thing of all.

"I am in favor of optimistic view," he said. "The opportunities and challenges for humans will continue very aggressively for a long period of time."

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