

The Pransky interview: Dr Raffaello D'Andrea, Founder, CEO, and Chairman of the board at Verity; Entrepreneur; Professor; Scientist and Artist

Joanne Pransky

Robotic Psychiatrist, Sonoma County, California, USA

Abstract

Purpose – The following article is a “Q&A interview” conducted by Joanne Pransky of Industrial Robot Journal as a method to impart the combined technological, business and personal experience of a prominent, robotic industry PhD and inventor regarding his pioneering efforts and the commercialization of bringing a technological invention to market. This paper aims to discuss these issues.

Design/methodology/approach – The interviewee is Dr Raffaello D'Andrea, a highly successful entrepreneur and proven business leader and one of the world's foremost leaders in robotics and machine learning. D'Andrea is Founder, CEO and Chairman of the Board at Verity, the world's leading autonomous indoor drone company, as well as a Professor of Dynamic Systems and Control at the Swiss Federal Institute of Technology (ETH) in Zurich. D'Andrea is also one of the co-founders and advisors of Robo-Global, an index and research company focused on investments in robotics, automation and artificial intelligence. In this interview, D'Andrea shares some of his business and personal experiences of working in industry and academia and his criteria for turning his ideas into successful working systems.

Findings – Raffaello D'Andrea's entire career is built on his ability to bridge theory and practice. D'Andrea combined his love for science with his need to create and received a BS degree in engineering science at the University of Toronto, where he was awarded the Wilson Medal as the top graduating student in 1991. He obtained both his MS and PhD degrees in electrical engineering at Caltech, and then he joined the Cornell faculty as an assistant professor. While on leave from Cornell, from 2003 to 2007, he co-founded the disruptive warehouse automation company Kiva Systems, where he led the systems architecture, robot design, robot navigation and coordination, and control algorithms efforts. In 2014, D'Andrea took robotics technology into the air and founded Verity, the world's first company to deliver a fully integrated autonomous, indoor drone-based system solution.

Originality/value – Raffaello D'Andrea combines academia, business and the arts to reinvent autonomous systems. D'Andrea was a founding member of the Systems Engineering Program at Cornell, where he established robot soccer as the flagship, multidisciplinary team project. In addition to pioneering the use of semi-definite programming for the design of distributed control systems, he went on to lead the Cornell Robot Soccer Team to win four world international RoboCup championships. Kiva Systems, co-founded by D'Andrea and acquired by Amazon in 2012, helped the re-branded Amazon Robotics to disrupt the entire warehousing and logistics systems industry. Additionally, D'Andrea is an internationally-exhibited new media artist, best known for the Robotic Chair (Ars Electronica, ARCO, London Art Fair, National Gallery of Canada) and Flight Assembled Architecture (FRAC Centre). With his team at Verity, he created the drone design and choreography for Cirque Du Soleil's Paramour on Broadway, Metallica's WorldWired Tour and Céline Dion's Courage Tour. Other D'Andrea creations include the Flying Machine Arena, where flying robots perform aerial acrobatics, juggle balls, balance poles and cooperate to build structures; the Distributed Flight Array, a flying platform consisting of multiple autonomous single propeller vehicles that are able to drive, dock with their peers and fly in a coordinated fashion; the Balancing Cube, a dynamic sculpture that can balance on any of its edges or corners and its little brother Cubli, a small cube that can jump up, balance and walk; Blind Juggling Machines that can juggle balls without seeing them, and without catching them. D'Andrea is also collaborating with scientists, engineers, and wingsuit pilots to create an actively controlled suit that will allow humans to take off and land at will, to gain altitude, even to perch, while preserving the intimacy of wingsuit flight. D'Andrea has received the IEEE Robotics and Automation Award, the Engelberger Robotics Award, the IEEE/IFR Invention and Entrepreneurship Award in Robotics and Automation and the Presidential Early Career Award for Scientists and Engineers. In 2020, he was inducted in the National Inventors Hall of Fame and elected to the National Academy of Engineering.

Keywords Control, Robotics, Sensors, Mobile robots, Autonomous robots, Unmanned aerial vehicles (UAV)

Paper type Case study

Pransky: From pioneering on-the-ground autonomous mobile robotic systems for warehousing, what led you to pioneer autonomous indoor drone systems for warehousing? (Figure 1)

D'Andrea: I would say that anything I do <https://raffaello.name> has to have a combination of the following:

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Figure 1 Founder, CEO and Chairman of the Board at Verity; Academic, Scientist, Artist and Entrepreneur



- It has to be barely doable. Figuring this out is an art.
- It has to have impact.
- I have to get to work with people who are enthusiastic, smart, creative and nice—and the more the better.

What we are creating at Verity has all those ingredients. Just like Kiva Systems (Figure 2).

Our work at Kiva also opened up my mind to the huge possibilities for robotics systems in the warehouse. I envisioned a fleet of self-flying drones doing jobs that were time-consuming, expensive, and dangerous. Bringing that vision to life checked every box—a, b, and c.

Pransky: In an automated warehouse, why do you need drones to check inventory – don't you already know where everything is? What causes inventory to get lost or misplaced?

D'Andrea: In a fully automated warehouse, each product or pallet enters through a gate where it is scanned and measured, sometimes in 3D. This catches label errors before a pallet enters storage. Once a pallet passes the gate it is stored automatically, making placement errors extremely rare. Unless a second, independent means of inventory verification is required, these facilities don't have a need to perform drone inventories. However, such facilities are few because of their cost and inflexibility. A fully automated warehouse costs in excess of US\$25m, compared to US\$1–5 m for a manually

Figure 2 Kiva Systems, co-founded in 2003 by D'Andrea and acquired by Amazon in 2012 for US\$775M, transformed the entire warehouse industry by enabling "goods-to-man" operations



operated warehouse. They are configured to store a specific size of pallet and not suitable for oversized goods. Reconfiguring racking configurations is a long and costly process.

This is why even in high-labor countries the vast majority of today's warehouses, around 95%, operate with very little automation. Goods are moved by humans on forklifts who scan in the inventory manually using handheld scanners. These scanners automatically update a warehouse management system – a digital twin of the warehouse that maintains a record of warehouse locations and the goods stored there. Drone inventories can add tremendous value to these warehouses since frequent, automatic checks keep that digital twin up to date, allowing a zero-error operation at relatively low cost while maintaining full flexibility (Figure 3).

Interestingly, we have found that even fully automated warehouses have a need for indoor drones, albeit not for inventory checks. Like all complex machines and plants, automated warehouses require constant monitoring and maintenance. A large facility will have dozens of issues each day. Only a fraction of them will cause a real disruption, but these disruptions can be extremely costly. Indoor drones can automate monitoring these assets by placing sensors where they are needed when they are needed, at a fraction of the cost of deploying sensor networks or performing repeated manual inspections. <https://verity.net>

Pransky: Can you tell us about the amazing Kedge™ localization system and also is this the same system that is used in warehouses?

D'Andrea: We have indeed created an RF-based localization system. It works similar to GPS – just by listening to a finite number of satellites (the so-called kedges), an unlimited number of receivers can figure out where they are in space. Not only position but also orientation. Unlike GPS, the kedges stay synchronized just by talking to each other. This is the system that we unveiled at TED in 2016 www.ted.com/talks/raffaello_d_andrea_meet_the_dazzling_flying_machines_of_the_future#t-682518. We have various other means for localizing indoors (Figure 4).

Pransky: What sensors do the drones have on board?

D'Andrea: Standard: cameras, inertial sensors, environmental sensors and wireless.

Figure 3 The Verity system is a complete, integrated inventory system powered by autonomous drone technology for the zero-error warehouse

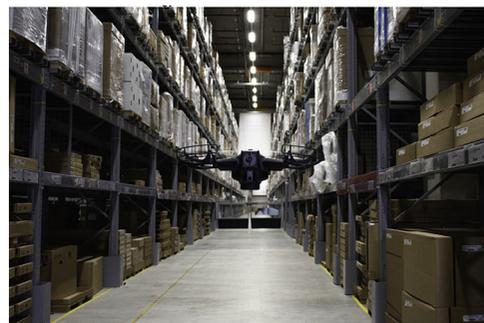
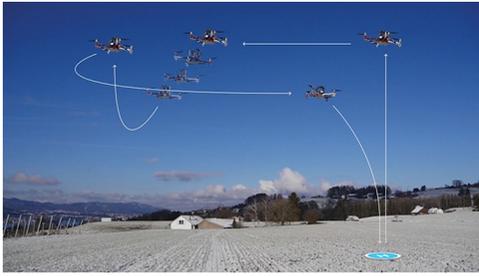


Figure 4 Verity's Failsafe technology is a patented solution for quadcopters that effectively guards against propulsion system failure



Pransky: You have cofounded highly successful companies in both the US and Europe and have taught at each of these country's universities. Can you briefly explain the "climate" of each and some of each country's pluses and minuses that may be helpful to PhD/graduate students considering a startup or teaching at a university?

D'Andrea: In the USA, it's easier to start a company and to get it funded. In Switzerland, it's easier to run a company sustainably by honoring the work-life balance so the people that bring it all together don't get burned out.

The same is true in academia. In the USA, PhD students practically live in their labs. They also watch way too many YouTube videos. In Switzerland students work hard, but they also play hard, often outdoors. Starting out as a professor in the USA is great, because it's like being thrown in deep water and having to figure out how to swim. It makes you tough—or it makes you give up and move onto something else. Coming to Switzerland as a full professor <https://idsc.ethz.ch>, I was thrilled not to have to spend all my time writing research grants or performing low-level administrative duties. Here, I can devote my time to actual research and teaching.

Pransky: Did you ever think of leaving one role for full-time in another – in other words, working full-time as either a professor or full-time at one of your company startups? Which role do you enjoy more?

D'Andrea: You mention tech startups and academia, but I've also co-founded the world's first robotics-focused exchange traded fund, www.roboglobal.com, which now has over US \$4bn in assets under management. I've created several installations that are in the permanent collections of art galleries. I teach and mentor brilliant students. All of these things may seem disparate, but they all have one thing in common: the act of creation.

Pransky: What do you think PhD and Masters of Engineering students should be doing while in school to prepare them best for the commercial side of robotics?

D'Andrea: The best advice I can give anyone is to chart your own way. When I was wrapping up my PhD at Caltech, I

interviewed for a post-doctoral position with a very famous professor at a top university. Near the end of my interview, he offered me the position, but he also said, "You are leading a schizophrenic existence. You should really figure out if you want to be an experimentalist or a theoretician; you can't be both." I turned the position down.

When I started as a professor at Cornell University still in my 20s, I decided that I wanted to get into autonomous mobile robots, so I started a large research and educational program centered around RoboCup, the world cup of robot soccer. I had never taught, let alone taken, a robotics class before (my PhD is in control systems). My colleagues told me that I was committing "academic suicide" (Figure 5).

We ended up winning the championship four times https://raffaello.name/wp-content/uploads/2013/09/RoboCup_Team_Cornell.pdf. The year-long class became a key ingredient in the Systems Engineering program we co-founded www.systemseng.cornell.edu/se, and many of the 200 alumni that went through the program and class are now leaders in their area.

I can go on and on with similar anecdotes. What they all have in common is not recklessness, but rather seizing opportunities when they present themselves. Don't get weighed down by conventional wisdom. Do your homework. Be self-critical. Work hard and smart. Embrace the unknown. And admit your mistakes so you always keep learning.

Pransky: As a "Founding Father" of many different types of robots, which one is your favorite robot "brainchild" and why?

D'Andrea: That's like asking someone "who is your favorite child?" I guess, like with human children, the answer depends on how well the kids have been behaving when asked [. . .]

Before I even try to tackle that question, I have to say that I don't actually create robots (Figure 6).

What I do is create systems that include "robots" (which is a tricky term in itself) as parts of the whole. I also don't do this on my own, but rather with teams of very talented individuals, across many disciplines.

That said, if I had to pick one favorite, I think it would be the system <https://veritystudios.com> we created for Cirque du Soleil's Broadway show Paramour. It consisted of eight self-flying lampshades which performed a tightly choreographed dance with the show's two lead performers (Figure 7).

The show ran 400 times and was completely client operated; once the lampshades were placed, the stage hands simply

Figure 5 Professor D'Andrea led his Cornell Robot Soccer Team to four world RoboCup championships



Figure 6 D’Andrea began creating systems as a child via real-world scientific experiments



Figure 7 Verity Studios’ self-flying drones performed 400 client-operated shows in Cirque du Soleil’s Paramour on Broadway (credits: Cirque du Soleil - PARAMOUR On Broadway at the Lyric Theatre. Pictured: Ruby Lewis as "Indigo" and Ryan Vona as "Joey" (C)2016, Cirque du Soleil Theatrical. Photo by Richard Termine)



pressed START to begin the show. It was an amazing feat. Imagine 1 kg autonomous lawnmowers flying directly over people’s heads [...] what can go wrong? Nothing did, but I can guarantee that you will not see anything like that again for a very long time, if ever.

What made this particularly memorable for me, beyond the sheer audacity of it all, was that I personally designed the drone choreographies for the show, along with the bulk of the tools to create them. The show also launched at the same time – literally – the birth of my second child, Ryan; the moment I landed in New

York for first rehearsals, I had to turn around immediately and fly back to Zurich because my wife was in emergency labor.

Pransky: What has been your proudest moment in your extraordinary career?

D’Andrea: I’ve had the privilege of mentoring people who are simply outstanding. My proudest moments are when I see them achieve and create great things, and knowing that I’ve played a role, however small, in that success.

Pransky: What is the biggest mistake or greatest lesson that you’ve learned?

D’Andrea: This one is easy: ALWAYS admit your mistakes. Not only is it liberating, but it’s also the best way to learn.

Pransky: What next invention is stirring in your consciousness?

D’Andrea: For the past eight years now, not counting all the time I’ve spent just thinking about the general area, I’ve been working on a paper in my spare time that has nothing to do with robotics or control systems, or anything else that one could point to from what is publicly available. I hope to release it soon.

About the author

Joanne Pransky has been an Associate Editor for Industrial Robot Journal since 1995. Joanne was also one of the co-founders and the Director of Marketing of the world’s first medical robotics journal, *The International Journal of Medical Robotics and Computer Assisted Surgery*. Joanne served as the Senior Sales and Marketing Executive for Sankyo Robotics, a world-leading manufacturer of industrial robot systems, for more than a decade. Joanne, also known around the globe as the World’s First Robotic Psychiatrist®, has consulted for some of the industry’s top robotic and entertainment organizations, including Robotic Industries Association, Motoman, Staubli, KUKA Robotics, STRobotics, DreamWorks, Warner Bros., as well as for Summit Entertainment’s film “Ender’s Game” in which she brought never-seen-before medical robots to the big screen. Joanne Pransky can be contacted at: joannepransky@gmail.com

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