I’m Prashant Nair, and welcome back to Science Sessions.

PS: There are more than 40 million blind individuals. Certainly their plight would be greatly ameliorated if one could come up with a prosthetic device.

Prosthetic devices like implanted hearing aids and artificial limbs have proven life-changing for millions of people with disabilities worldwide. But for decades, researchers have been trying to fashion a visual prosthetic device, or what’s sometimes called a bionic eye, for blind people. Some devices like artificial retinal implants are already helping a small number of previously blind people navigate the world by restoring partial vision. But a working device that can restore sight by directly stimulating the area of the brain that mediates vision is still a formidable challenge. Neuroscientist Peter Schiller is taking the first steps to address that challenge at MIT’s Brain and Cognitive Sciences Institute. He is exploring the possibility of developing an implantable visual prosthetic that would combine a camera, an algorithm, and an array of tiny electrodes to help restore sight to the blind.

PS: Regarding the question of a prosthetic device for the blind, a great deal of effort is being expended trying to come up with such a device. For example, electrical microstimulation of various brain areas. My line of work has been studying electrical stimulation in the visual cortex. We feel the visual cortex is a promising candidate because it’s a relatively large area. It has a nice topographic layout of the visual field, meaning that the visual field is laid out in a rather nice, orderly fashion on the cortical surface. If one were to stimulate these areas that have this kind of nice topography, possibly through the input from a camera that sends its images to a computer, which then would drive an array of electrodes implanted in the brain, could recreate visual percept.

That’s an idea that sounds elegantly simple. But it’s riddled with difficulties.

PS: Well, the fact is that at this stage we do not have a prosthetic device that is truly working. There are several challenges. You need to implant a whole array of electrodes, several hundreds of these electrodes. The biggest problem there is can you implant such a device that will then last for many, many years. The second big requirement is you need to sort of mimic what the activation of these cortical regions would be like under real conditions. Each neuron in the visual cortex is sensitive to a teeny, teeny little portion of the visual field, and most of these neurons respond to changes in the visual field. So in other words, these neurons are inactive until an edge or small spot appears in their teeny little receptive field, and then the neuron fires away vigorously, signaling that there’s something out there. Tens of thousands of neurons firing away in various patterns—that can give you a sense of what the object is. The appropriate algorithm, as we call it, for this transfer, say, from a camera that responds only to changes in the visual field is the requirement. So this algorithm needs to be developed which then mimics the natural response characteristics of these neurons.
And even if those challenges were to be successfully overcome, Schiller would have to find a way to endow the prosthetic device with the ability for depth perception. It’s often taken for granted, but vision is a sort of two-in-one package deal: Our eyes not only help us see things around us, but they also help us perceive the relative depths of objects moving around in three-dimensional space.

**PS:** The next big problem is to recreate depth perception in individuals who have a prosthetic device implanted. How we perceive things in three dimensions is one of the major achievements and problems for living organisms. Because images fall on a two-dimensional surface of the retina from which the brain has to compute where various objects appear in depth in the visual scene. Several mechanisms have evolved, which include motion parallax, which is based on the physical fact that objects at different distances from the eye move at different rates across the retinal surface. And it just so happens that motion parallax is a natural outcome of us moving around in space, and so consequently a properly set up camera with a proper algorithm that would stimulate the visual cortex through this array of implanted electrodes, would automatically have the capacity for motion parallax. Objects at different distances from the camera would be moving across the surface of the camera itself at different rates and consequently would activate the cortical tissue at different rates, thereby providing the very important aspect of differential rate of motion, which then is converted by computation in the brain to depth perception.

You can learn more about Schiller’s work in his “Profile” and “Inaugural Article” published in PNAS.