Shun-Ichi Amari: Okay, thank you for coming everybody. It's my great honor and pleasure to be here in San Diego, and I will deliver a short lecture looking back on my life. How I studied and how [inaudible 00:05:51] . I never dreamed of getting the Kyoto Prize, it was a big surprise, the package on my door. My life has been lucky. It's very lucky. I loved mathematics in my elementary and high school days. One of the things I remember, is the high school teacher took us to the University of Kyoto mathematics, mathematics department. And they had on the board some interesting problems. And if we can solve one of them, then they gave one piece of a pencil. And I tried many solutions. But one thing I couldn't solve is this problem. So X power equal X power Y equals Y power X. X is two Y equal four is the answer. And the question [inaudible 00:07:12] all the rational numbers [inaudible 00:07:18]. I tried. I couldn't so I go back home. After dinner I also think of [inaudible 00:07:34] maybe [inaudible 00:07:34] . I got idea and next day I [inaudible 00:07:38] University of Tokyo. So I solved it. One pencil. However, when I prepared this slide. I tried to solve this problem. I couldn't. So, maybe I'm not better in my high school [inaudible 00:08:05] and I entered the University of Tokyo. I struggled to become some researcher in science or engineering. However, there is a lot of peace movement or movement against government or against America imperialism. And I was involved in that movement. What does [inaudible 00:08:34]. After one and a half years they decide which course you choose the higher education. And say mathematics department, physics department, electrical engineering department, those require very high score. But my skill was low, unfortunately. So I thought at that time, there was some explanation that some researcher some professors created a new course named mathematical Engineer. Okay? The friends of those professors, They worked in aeronautics in the world wide war second then Japan was defeated that, you know, and they prohibit research on aeronautics. It might be dangerous. And so those professors changed the name into applied mathematics. But after the [inaudible 00:10:03] , it end the prohibition, they come back created new aeronautics department, [inaudible 00:10:14] and joyfully, I went back to those new department. But some strange professor, so no more aeronautics. Okay, it's too narrow. We should apply much wider and apply modern mathematics. The main engineering or some other problems. So they created mathematic engineering course, very small course. Professor are only four, but the students are five. Okay. And so, and at that time, they are yeah, they themselves are just struggling to found a new mathematical engineer. Okay? So they did very hard work. They worked hard. So this is maybe the beginning of my very lucky life, okay? And they say, Professor, you are free. You can do anything you want, okay? For mathematical, science and engineering. But you should open your eyes very wide. And to think about any phenomena or problems to [inaudible 00:11:44] , if you like it, you should do it deeply, but never on the inside, your eye should be much larger. So, I mentioned the mathematical engineering. Then mathematical engineering. It sounded not so strange. But at that time, it was very strange and mathematical science still, not a popular. Mathematics, very popular. In Japan, pure mathematics is a top in the world. They say application of mathematics. That nonsense. Okay? Those two dropped out, [inaudible 00:12:40] application of mathematics. Mathematician should be purer and purer. But, as I mentioned, it is beginning of my luck. So my graduate study is say very different subject. In master course, I try to analyze electrical networks. It has some combinatorial structure, and I used modern homology theory to solve those problems in terms of algebraic and topology. And then I try to differential geometry of material. Very different field. The material, there's a lot of fine structure. They call it dislocation and fracture material happened by motion dislocation. And it is very good. Described by Riemannian Geometry, it is one tablet my professor created, but at the same time in the UK or in Germany, similar theory appear and they discussed a lot of things. Finally, I have interesting something [inaudible 00:14:28] theory. I'm very impressed by reading [inaudible 00:14:34] theory book. And I tried to make some theory of single transformation or singular transformation in terms of geometry. This is my Ph.D. study. Okay. I was very lucky because at that time, in Japan, they say, and technology engineering, science, very important. Maybe the influence [inaudible 00:15:10] Russia unique then the government decided to enlarge those science and engineering department. Implies they created a lot of new professor position. So there are a lot of [inaudible 00:15:35] . After the graduation I [inaudible 00:15:40] , they become the associate professor at the Kyushu University.

Okay. And to my surprise and to my luck. And in Kyushu University, I studied what subjects interesting. At that time, Perceptron is invented by Rosenblatt, an American psychologist. He proposed some learning machine. Machine should learn as our brain. Okay? And then we can create some artificial intelligence things. Now there's another school of artificial intelligence. But the Rosenblatt, so that certain [inaudible 00:16:37] neural networks. And to train that one, maybe the universal artificial intelligence machine can be realized. But at that time, it's impossible. The computer facility computability is so poor. They cannot handle the problem that you're interested in. At that time, however, the theory of learning machine is very interesting. And at that time, only the last day neuron we can learn. We can train only last neuron and intermediate neurons, if we could train it too, and maybe it much higher bit. But at that time, it's impossible. Why? The reason is they used 01 combinatorial neuron. They called McCulloch-Pitts neurons. However, if we use a narrow type neuron, now they use a narrow type neuron. Then, if we change the connection weights everywhere slightly, we can find the effects. It gives to the last neurons of the neurons. That, in mathematics, it's a differentiation. If there are many snaps, it's gradient. I proposed gradient [inaudible 00:18:30] of the train, certain neural network, it's so simple. It's so obvious. But at that time, no one said so. I tried, and I did computer simulation. It worked well. To my surprise, after 20 years later, some American professor, including Hinton rediscovered this type of learning method. But at the same time, I am interested in why our brain works so well. It's like neural networks here. But it works really well. I just studied something physiology, neuroscience, book, very difficult. But reading, they describe details of neurons, synapses, and [inaudible 00:19:38] . But still, how we think the unknown. Even now, it's unknown. We have mind, we have consciousness. We can do mathematics in the brain. Brain surely can do that, but it's a very different thing. I think maybe we use some mathematical model, simplified model of neural networks. But analyze deeply those simple model. It's simple. We can do analyze and just study, what is the ability and disability or limitation of this simple model, then we can go one step further to understand what their brain works. It's mathematical neuroscience. Some physiologist, my friend, said, Amari, you are doing the theory in the head. We are doing theory experiment on the half using monkey, rats, all those things. You are the heavenly, academia. Yes. I think it's okay. But still now, mathematical neuroscience is going on, and it's becoming more and more important. Then, in 1975, I visited America. Michel Arbib, he's here, invited me to join his laboratory. Also, he has an interest in brain, mathematics, and combination on those things. I think my English is very poor still now, but maybe if I visit America, maybe my English becomes much better. My daughter, one of them here, speak English very fluent. I'm not. But and nine months of the life in America, it opened my eyes very widely to the international academia. At the university, there are many visitors from all over the world. They do speak, and students hear those things, becoming they are very internationally educated. Unfortunately, yes, in the airplane from Japan to America, it's a Korean airline. At that time, they request [inaudible 00:23:12] to put the earphone and to watch the movie. I tried, totally, not understanding. At that time, I felt okay in the town flight. I can understand very well that movie. However, the entire flight, I paid $3. But still, it was very different. But one thing interesting, I traveled from Massachusetts to California by car, taking three months, a long travel, looking very night, sightseeing places. Now here is some picture, I was young, obviously, and my daughter smallest [inaudible 00:24:14] here. Then the 1985, [inaudible 00:24:27] , they say the neuron-like machine can do something very good, internationally, a big write-up on neural network research. But before that, it's called winter period and those neural networks or artificial digits. But in Japan, we don't have any budget in America, Europe. The large budget or this subject because it looks useless. In Japan, we have almost no budget for research. For them, that [inaudible 00:25:22], we have freedom instead to do our research, really and we tried to think about mathematical neuroscience or machine learning, and we collaborated with those neuroscientists. They are working on the ground. I'm working on the table. Then, Japan became something advanced country in theory of neural networks. I'm one of those who did many of those stochastic gradient descent learning method, I did associative module model for neuro fluid dynamics and many of these things. Then, suddenly, at that time, still, the Japan financial economy is going up, but still university, it's difficult to go abroad. Then I met Michel Arbib,

and after that, he invited me to visit America. Then there was a boom in 1985. Suddenly, a telephone call came to me. At that time, no direct telephone; the university took some place of telephone, and they called me Professor Amari, here is the international call from America. It's English. But I couldn't do it. [inaudible 00:27:26] connect. It's the Neural [inaudible 00:27:32] Neural Network Conference in America. It is in San Diego. They say they'd like to invite me as a speaker. All the expenses they pay. I said, yes. This is the beginning, my debut of international community. Then Japan got better and better some difficult so quickly. There are a lot of one to go abroad. Then after that, I did reach, but some time after, then I did research on the mathematical neuroscience or machine learning about 10 years. Then I felt I was an expert on this subject, doing many things. It's maybe that that might be big mistake. I should search for other interesting field to take. I think something at the time, the information scientists say homotopic science or [inaudible 00:29:26] , or those dealing with information, they use algebra, the mathematical analysis, mathematical logic, and those things. But we couldn't find any geometrical set. Geometry is a wider perspective. We need the science of information. I just worked on the statistics. Statistics, they use the not single probability, but other candidates to estimate a family of probability distributions, say the Gaussian distribution. It has something meaningful. In Gaussian case, say simple [inaudible 00:30:33] with two dimension. What is the two-dimensional Gaussian distribution? What its structure is? We need some principle. The idea if we are given a number of the observation from one distribution, we have a graph form of that distribution. Its histogram right this way. We need a very smooth two-dimensional Gaussian distribution. We need to project this observation in the two-dimensional manifold of probability distribution. Then, what is the prediction? Prediction is just a straight run. Such that it crosses at a right angle. But what is a right angle? We need something metric to define the right angle. We need a fine connection to be what is a straight run. Of course, it's a curved space to view the learn of differential geometry. I tried those things very hard and I was very happy. I met Sir David Cox in Japan and presented him my idea, my design of the differential geometry or statistics. Cox said almost nothing. After returning to London, he wrote me, your idea might be opening a new way to statistics. We need to study, check those ideas internationally. He organized a workshop on differential geometry or statistics in London. I was invited. I've met many famous statistics people. One of them is C.R. Rao. He died two years ago, at the age of 103. Cox died also, maybe nearly 100. [inaudible 00:33:50] from America, and Efron from Stanford came. So, Cox recommended me to many international conferences to be a speaker so that the idea of neural and [inaudible 00:34:11] spreads widely. This was very lucky. At that time, I met Komarov in Russia. Of course, he died now. But those things very lucky. I called my theory information geometry. It was geometry of statistics. Maybe statistics geometry might be better, but I think, no, it's not limited to statistics. It should be open to more wider subjects and now information geometry is applied to many areas of physics, mathematics, and so on. It becomes wider and wider. Of course, we use information geometry to analyze an intelligence while the studying the ability of those deep neural networks. But also, it's happy that and okay, and spring up people and visit me. There's a Japan chapter of spring. When they visit me, we are thinking about to publish a new journal, Information Geometry. How do you think about that? I said, oh great idea. However, it's not profitable. There is already that. At that time spilling out people, no no no we are looking for the 10, 20 years later, it might harm big audience, big leaders. We are just setting such science. It develops 20 years later. We think Information Geometry might be such one. I'm so glad. It's now 80 years after, and Springer just united to his nature, and they're such more profitable journals. They say, there's a problem in continuing Information Geometry. There are not so many leaders, they contributors. That's the problem. They are in fact doing very well. I mentioned second neuro boom happened, but still, unfortunately, the neural network technology. We cannot use it. The other time computer facility running, not so good. Still, not so good. It's much better than the other time, but still not good. Now the thought was of course AI boom, neuro network boom is coming, okay? I was astonished at seeing those new AI technology, say ChatGPT. They do very well. Gen AI and special. I cannot use that word, but to see very helpful to doing something and writing a letter of congratulations which I think I'll ask to write, okay? Now, I draw the rough manuscript, asks ChatGPT

to read make it much better. They do very simple thinking. I studied English for the 60 years or more, still very well. But AI much, much better. It's very surprising. Much better. Yes, at that time, retirement of University of Tokyo or the 60 then I should retire and just to search for some another job and there the RIKEN that is Physical and Chemical Science Institute in Japan and Masao Ito for the neuroscientist found that it's neuroscience inside RIKEN. Then Ito invited me, Amari son RIKEN is very good. Why are you not joining us? I joined, it's a paradise. Lot of research funds, and working much more science. We don't need any big funds. But we have a lot of the thing and I do research free. Also artificial intelligence or special neuroscience by using information in the geometry. At the age of 80, I retire. I think, okay, it's very free time and science of the thing I continue as my hobby. Now, I like to play Go game. It's like chess, okay? Then the COVID got here. After retirement and I visit the RIKEN every day, but just a COVID came, they say, don't come to RIKEN, said once a week is okay. I'm still reaching RIKEN once a week to play Go game. Now I'm astonished at the power of artificial intelligence and to think about what is the difference from human and artificial intelligence. Present AI is so wonderful and progress is so rapid. Maybe next year, much better, next one, next much better. I believe our brain is much more powerful. Something wonderful. Then, in this period as scientists what our society, our culture is to go. There are lots of optimism and pessimisms. Some would say, AI [inaudible 00:42:48] , think paradise, we can live in paradise. All productive works done by AI. We don't do anything. But we have sufficient basic income. Not small income. Sufficient in price every day. Good wines. Good beers and very delicious foods. It's enough. Do you think this is happy society? I don't think so. It's not paradise, but it domestication of humans by AI. You see the pig or chicken or those animals. They can eat freely. Are they happy? I don't know. They don't know too. But for human, such a life is not happy. Human likes to work because our brain and human are the result of evolution. Our evolution, human society. Then, those by evolution, we reach to our mind, consciousness, and logic, mathematics, science, and so on. To work is by the [inaudible 00:44:53] . We need to work. We need to communicate with our other humans. It's society. The feeling we do work and do something accomplishment, feeling of accomplishment. That are very joyful. We did. We did this, okay? We need to work, even if there are no pay, but the food and drinks from the other side free because we never stop working. Work is sometimes painful. But after accomplishing it, it's changed into very joyful structure. Pain and joy just integrate it and we want to work by something to create, to generate or just from curiosity. Maybe, what is the work? We need to create works. That okay? Amateur work is okay. Amateur science very good. Now they say the science compete to each other. This discovery, I'm [inaudible 00:46:34] than you one day. Then let's keep that it's progress secret. That ridiculous. We really discuss it. There could be many simultaneous discoveries inwards overall. Which is earlier, that no problem. We enjoy together all our findings are very close, not great. Then, that work is just to play. Work and play united. Also the painful work and the joyful work is united. That is our society should go. However, have to reach that paradise. There are a lot crisis say military use of AI is now very fashionable. It might go to the worldwide war. Also, the AI is promoted by those big money companies. They want to earn money. They do proceed AI only for money. That are very dangerous. From that, disparity of people might increase, increase, increase. Politically, there are a lot of populism. Also, AI might help with the rights of populism and we're thinking about just our society civilization, the freedom, and equality and the dignity of humans, those things we should keep and we should create not domestication, but some new civilization to a our future society. Of course, education is very important. How to retrieve the AI. AI's dangerous because and it's very useful. We ask AI to do this work. They did. That implies our thinking is decreasing. Joy of thinking or opinion think it's very important. Sometimes we think about deeply, one day, one month, even 10 years. Some time the very good idea came into our mind. That's a very joyful thing. I hope that you should create new society, new civilization. Many of you, I'm not satisfied with the current situation or civilization or a political situation. But there are a lot of difficulty in conquering and create new civilization. It's up to you. It's no more me. I'm just looking, and maybe I live only a few years. But it's you who create a new [inaudible 00:51:05] civilization. Yes, paradise of human beings. Thank you very much. Thank you.

Rose Yu: Thank you very much. Amari Shun-Ichi for the very inspiring talk. This is a time for question and answering. We have students here. Anybody have questions for Amari Shun-Ichi please line up behind the mic.

Speaker 1: Which open problem in information geometry or neural computation. What do you consider the most important?

Shun-Ichi Amari: Yeah. I think Meta AI or Large Language Model develop so quickly and they believe bigger is better. Those skill of neural networks becoming larger and larger and basically, it worked. But there should be some limits. Now, I feel we don't have enough theory to explain why the current neural networks or transformers, all those things work so weird. It's poverty of theory now. We say big AI, they are created. They need big grant. But without certain large money, we can create theories. Those thing is open to not America or China, but even Japan. Japan is now poor. Not poor as six years ago. It is still a risk. But we can do that. So it's a mission of surgical passing to understand why it works so good. They say something emerging. But what emerging? We don't know. So maybe we can think about new theory, which makes it possible to construct a smaller scale, very wide actions.

Speaker 1: [FOREIGN]

Rose Yu: Let's take a question from my left hand side.

Speaker 2: Hello. My name is Isabella. I'm from Tijuana, Mexico. My question is, with the evolution of AI, how is the new generation? Can we still live freely as a society to continue to develop the use of AI to do good and not create danger and live in this paradise that you talk about?

Shun-Ichi Amari: I do not understand. Talk slowly.

Rose Yu: So would you mind the last part of the question be slow.

Speaker 2: I'm going to read.

Rose Yu: She wanted to know how we would live with AI in modern days as they are becoming so powerful. Then really, I guess, as a newer generation, to really live in this paradise that you were describing before. What is the optimal relationship that we should develop with AI?

Shun-Ichi Amari: That's a very difficult question. Nobody knows the answer. But we should find the way. Now so those war are going on. Also the disparity of people increasing. They have to overcome this bad situation. We don't know. We know also and democracy is something in Christ. Under the democracy, there are Satan, Hitler or those people might keep it. So we simply think about to be from the very side. Of course, from AI side and smarter still small scale AI prevailing for other people. Also, the decision between our neighbors. It's really important under democracy to keep democracy. Those things are all up to you. Not me. Yes. Good.

Speaker 2: Thank you.

Speaker 3: Hi, my name is Erin Alape. Throughout your presentation, you mentioned lots of changing situations like the way you experience your education, different cultures, different languages, and even the change in our critical thinking skills that AI has inevitably brought. So I wanted to ask, what could you share to us, young folks about overcoming change in such a technological era?

Shun-Ichi Amari: So, we cannot stop development of technology. It's so powerful and it's so convenient. The modern AI so helpful. We should use it. But AI, it's not the AI use ourselves to find the answer. The important thing we should use, thinking, considering, very carefully. Don't rely on the answer of AI, there might be lots of hallucination. So, I'm very afraid of the people, the child, can you use AI very conveniently. So we should not lose our thinking ability, joy of thinking, and all those

thinking deeply, say one year. Maybe suddenly a new idea come up with my mind. That those new idea, AI cannot do. So we are very careful not losing our working, thinking, and communicating to each other. Not communicate with AI, but communicate with the human. That's a very important factor, I think.

Rose Yu: Thank you. I can take a question from my right hand side.

Speaker 4: [FOREIGN] My question is, you talked before about your work in geometrical information, and I wanted to ask is this different information for conscious, and if it is, how can we describe it mathematically, consciousness?

Shun-Ichi Amari: What is the last part of the question? Information?

Rose Yu: Information of our consciousness.

Shun-Ichi Amari: Consciousness.

Rose Yu: Yes.

Speaker 4: Can it be described by mathematics?

Shun-Ichi Amari: Yes. Consciousness is a big problem. It emerged in our mind and brain by evolution. I think the consciousness, it's such a simple thing that I know what I want to do by myself. That's important to communicate to each other. When we work together, we need to transmit some idea I'm intending to do to the other people. So that being of the consciousness. Recently, there are some theories of consciousness in the say information and integrated theory or those things. But still, insufficient. Consciousness is part of our mind that evolved through long history. So, simple thing or machine to have consciousness. That is if machine or AI knows what they are doing now, currently, maybe after following prompt, they are doing some work. But if AI understand the true meaning of prompt put and task which they do themselves, they do [inaudible 01:02:02] some reason. Currently the stochastic reading is logical. But they should do more logical part, and now the logical part is going on, but I have to combine nicely those stochastic thinking and logical thinking and knowing when the intention those thing is necessary for the future math, and it's a being of consciousness. But consciousness is much more delicate things. I believe if there is a machine, AI who has personality, it won`t seem to sense of justice and so on. It's very dangerous. One can easily create machine like Trump. Everything is there. If we got money, that's okay. I am great. Or Hitler or Putin or there are many such people. Now, if such AI emerge, it's so dangerous. This is a problem of the personality or consciousness and the machine.

Speaker 4: Hi, [FOREIGN] .

Shun-Ichi Amari: Hi.

Rose Yu: You have a question?

Speaker 5: Hello, Dr. Amari. It's a pleasure to meet you. My name is Camila Ela. I really admire your career and your work. I would like to ask you, do you think artificial intelligence will ever surpass human intelligence?

Rose Yu: Whether artificial intelligence will eventually surpass human intelligence?

Shun-Ichi Amari: A very different question? Human intelligent, say some scientist knew to Einstein. Then our user did and also the current AI, they do interpret a prompt. You're thinking about many examples. They think this new situation should be set and sun. However, human do not satisfy with those. They got given problem they would answer. It's okay, but it's not such. From ancient to date,

they know the movement of stars and they have some law how stars going on and even all the time, they can do such interpolation. However, they don't ask why. But anyway, the Kepler find that this planet go around the sun in something in like down more so. It explained every situation very well. But Newton did not satisfy with good answer. Why? Why is an answer about us while other planet go around. And he invented something, the law of gravity, the concept of force or concept of mass, acceleration, something very new things and combine those thing and create a new unified theory. The current AI couldn't do that. In future, is it possible we need some motivation or curiosity to ask further and further. And it's very difficult shall be the current AI to have that curiosity. I cannot say anything about in future. It might be possible. But it takes some years, I guess. You got it by evolution of many, many, many years.

Rose Yu: Great. Thank you, Amari. What's the question from my left hand side?

Speaker 6: Good afternoon. My name is Al Renoso. I'm from Lazaro Cardenas High School in Tijuana, California. I wanted to ask you what advice would you give to young students who want to contribute to future of AI and what skills or fields should we focus on studying?

Rose Yu: So, he wanted to know, as for young people, do you have advice about what skills and subjects of learning that they should focus.

Shun-Ichi Amari: It's a very difficult question. I say, don't stop using AI. It's very convenient, too. But remember you use the AI. You are the master. And you think as things don't AI know the answer which computer gives. You should think about is it right or no? So I'll advise you not take easygoing way. Whatever the AI is useful, convenient. Don't rely on that. At the same time, you should consider, think about the whole story

Rose Yu: of the world and the problem you are facing. We'll take one last question from this side.

Speaker 7: Hello. My name is [inaudible 01:08:58], and I'm from Southwest High School. I wanted to know your opinion about AI wasting natural resources for us.

Rose Yu: So she is pointing the fact that says modern AI models use a lot of energy to train these models. What is your opinion about that?

Shun-Ichi Amari: Now, the AI is very energy consuming. It cannot continue further. But maybe, I don't know 10 years or 20 years or something, we invent new technology. We need not so great energy. A brain works they say only 20 watt power. That is like the small tube. So energy problem now the big obstacle making the AI and [inaudible 01:10:03] . But I think not near future, but in some future, we can invent new technology, how to conquer that problem.

Rose Yu: Sounds good. Let's hand again to your student last question and especially Amari Sensei for the wonderful QA. [APPLAUSE]