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## **WHY ROBOTS WILL NEVER HAVE SEX**

*An Answer to Our Famous*

*But Not Very Bright*

*Futurists*

*Talk originally given in 2007*

*typos corrected in 2009; further cleanup in 2017*

**Avinash Kak**

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## *Preface*

A number of very respectable (and influential) people in this country are convinced that we as humans are doomed and that, sooner or later, robotic intelligence will far exceed human intelligence. Some will even go as far as to say that this will happen in the first half of this century.

This presentation is an answer to such folks.

I first put together this presentation when I was invited by Dr. H. J. Siegel, a highly respected professor of electrical and computer engineering at Colorado State University, to give a talk in their ISTeC Distinguished Lectures seminar series. Since I had known Prof. Siegel for a long time, I decided to use this occasion to extract my “revenge” for all the torments he had inflicted on me during his years at Purdue.<sup>1</sup> Since computer science and computer engineering

<sup>1</sup>Here is one of the tamer such torments: On my fortieth birthday, HJ arranged for me to be driven to a tavern at the other end of town in an old open firetruck with its bell clanging. Several of our mutual friends had gathered there — about 40 of them if memory serves — and they all proceeded to get drunk on margaritas at my expense.

seminars do not typically mention sex, I figured my talk would at least cause him some discomfort, if not outright embarrassment.

Regardless of the original reason for this presentation, my goal here is serious — to respond to folks who are convinced that some day robots will rule the world. As I point out, every deep thinker, from our past and from our midst, has a different opinion on what constitutes intelligence. I present the viewpoints on intelligence as espoused by the different scientific communities that have a vested interest in defining and understanding the notion of intelligence. I also quote some highly renowned psychologists and philosophers who have played important roles in giving us a sense of who we are as humans. As I mention, all of these viewpoints on intelligence are equally valid — they are simply different perspectives on something that is so beyond rational analysis.

So the reality is that there does not exist a universally agreed-upon definition of what constitutes intelligence; it is a human quality much like beauty, emotion, passion, etc. We recognize intelligence when we encounter it, but we cannot capture it in a measurable definition. This lack of a proper definition of intelligence is my main argument against folks who are so gung-ho about the prospects of robotic intelligence.

This is a multi-media presentation. In the middle, I show a 2-minute segment from the movie “Bicentennial Man” to illustrate the error of attempting to judge the intelligence of a machine by engaging it in a

human-like conversation — this is the mainstay of what is known as the Turing Test.

Finally, I end the presentation by playing a sound recording that is a blend of Vivaldi’s “Four Seasons” and the pop tune “Please Don’t Let Me Be Misunderstood” by The Animals. This is to demonstrate the magical ability of the human mind to keep track of each component of the mixture separately although they are being played simultaneously — a human ability that is not reproducible in a computer.

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## Why Robots Will Never Have Sex



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As you can see from the slide, I wish to remain anonymous.

The reason for that should be obvious — we live in a country that is largely conservative and puritanical, a country in which it is not always safe to talk about sex.

One of the central tenets of conservatism is that thou shall not talk about sex and thou shall not think about sex. If you don't think about sex, you'd never have a need for sex. That way you can remain chaste for ever. And purity is what conservatism is all about.

I have to get one more issue out of the way before I dive into this talk.

How many of you are here because of the word 'sex' in the title of my talk? You certainly do not believe that I am going to destroy my career by showing you titillating pictures.

So if you came here expecting to see raunchy images and listen to a dirty talk, you made a big mistake. For such folks, this would be a good time to leave.

# 2

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## Contents:

- A quick overview of the current generation of humanoids (**these are robots that look like humans and, in some ways, try to act like humans**)
- Quotes from some very well-known “futurists” regarding robotic intelligence and how **they think** it will evolve
- Definitions of intelligence as stated by various scientific constituencies

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This and the next two slides give you an overview of what in this talk:

I will start with a brief overview of the current generation of humanoids. These are robots that, to varying degrees, look like humans and, in some ways, try to act like humans.

I will then present quotes from some very well-known “futurists” regarding robotic intelligence and how they think it will evolve vis-a-vis human intelligence.

The futurists whom I will quote are not lightweight people by any stretch of imagination. They represent people who have been honored by the presidents of the United States. They are people whose opinions carry a lot of weight in many circles.

In order to gain a perspective on the predictions of the futurists, I will later present various definitions of intelligence as used by several different scientific constituencies. However, before getting to those definitions, I will show a movie segment as mentioned on the next slide.

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## Contents (contd.) :

- A 2 minute segment from the movie **Bicentennial Man** starring Robin Williams as Andrew the Android (and also starring Sam Neills, Embeth Davidtz, Wendy Crewson, etc.)



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I will show a 2-minute segment from the movie **Bicentennial Man** starring

- Robin Williams
- Embeth Davidtz
- Sam Neill
- Wendy Crewson

This movie segment is a perfect rejoinder to those who wish to judge the intelligence of a machine by engaging it in a human-like conversation.

# 4

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## Contents (contd.):

- Intelligence as defined by two prominent psychologists
- Intelligence as defined by two philosophers who have exercised considerable influence on Western thought
- AI vs. RI
- Robotic Intelligence related work done in my own laboratory

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I will then present the definition of intelligence used by two very prominent psychologists:

**Robert Sternberg:** President of American Psychology Association  
Past IBM Professor of Psychology at Yale and now the Dean of Humanities at Tufts.

**Howard Gardner:** Professor of Psychology at Harvard famous for many books, including one titled **Frames of Mind**

Subsequently, I will tell you how intelligence was defined by two great philosophers:

**Baruch Spinoza:** A founding ethicist of Western Civilization Also laid the foundations of Biblical Criticism

**John Dewey:** Considered to be one of the greatest American philosophers. How early education is set up in the United States — especially with regard to its emphasis on the development of the individuality — can be traced back to John Dewey's writings and influence.

*This side left blank intentionally*

This critical examination of intelligence will set us up to talk about Artificial Intelligence (AI) and Robotic Intelligence (RI).

Finally, I will present some of state-of-the-art work done in my lab at Purdue on Robotic Intelligence.

And, very finally, I'll show you a slide that will justify the title of my talk — especially its mention of sex by robots.

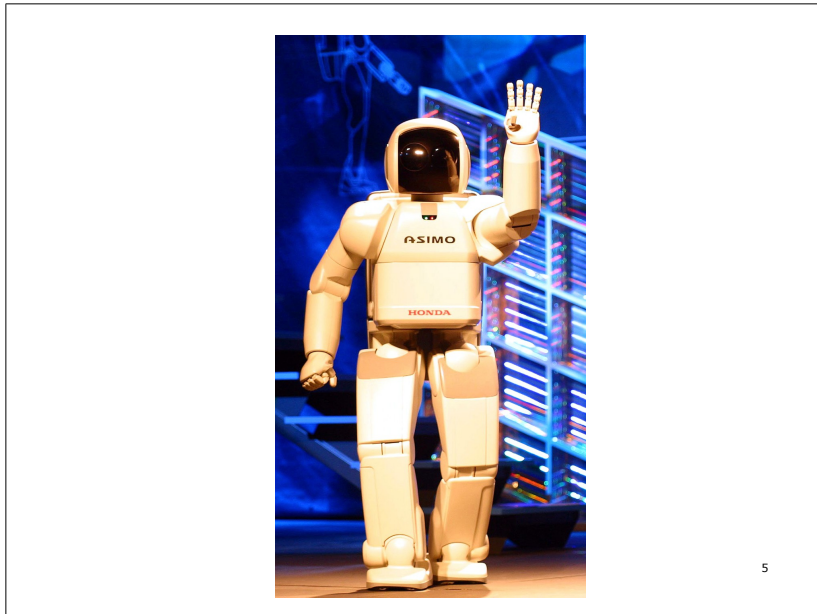
So if I run out of time when I am talking about AI and RI, please make sure I remember to show you the final slide since that is the only slide that talks specifically about sex.

I will conclude my talk by playing a recording that is a juxtaposition of “Four Seasons” by Vivaldi and a pop tune by the Animals. This is to demonstrate how the human brain, with its seemingly magical powers, is able to keep track of each of the two components of the recording. We do not know how to even begin programming computers to achieve the same result. This is just one of the many manifestations of the human mind that are beyond our rational understanding.



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So let's start with a brief survey of the humanoids.

As I mentioned previously, humanoids are robots that are designed to look like humans and in some ways to act like humans.

The modern international competition in humanoids started with this robot that is the culmination of 20 years of research by an extremely dedicated team of researchers at Honda in Japan.

This robot made its debut in 2000 and its development has continued since then. The more recent versions of this robot can

- walk comfortably at 1.7 miles an hour on an uneven surface
- run at close to 4 miles an hour,
- climb stairs and grasp objects
- comprehend simple voice commands and respond to them
- make simple maps of the space/physical-environment around it so that it can remember where it has been
- recognize a small number of faces in good illumination conditions

This robot is named ASIMO (for Advanced Step in Innovative Mobility) The robot is 4' 3" tall and weighs 119 pounds.

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## Asimo and Actroid:



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The robot on the right is known as the **Actroid J-Girl**

This robot was shown at the 2005 Tokyo International Robot Expo.

There are videos on the internet showing the robot making gestures, waving at crowds, expressing herself (itself?) through body language, and, I believe, singing.

This robot can speak multiple languages.

As of the last time I looked into this robot, its ability was confined primarily to its torso. That is, the robot does its thing without moving its feet.

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## Another Japanese Humanoid (Repilee):



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This robot, named Repilee, is the creation of Professor Ishiguro at Osaka University in Japan. This robot was unveiled to the media in 2005.

Repilee can flutter her eyes and move her hands like a human. She also appears to breathe.

Repilee has 47 actuators in the torso that allow her to turn her head in nine different directions and raise her arm in different sorts of gestures.

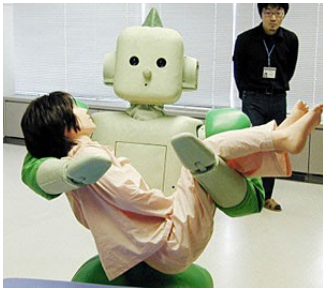
Sensors placed under the skin on her arms allow her to respond in different ways to any pressure applied to the arms.

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## Robot Carrying a Human Woman and a Robot “Experiencing Pain”:



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Before I move on to the humanoids from other countries, I want to show a couple of additional images from the Japanese humanoid research.

The left image shows a robot carrying a human woman. As to what purpose, I do not know. I figured that this image was relevant to my talk on robot sex.

The right image shows a robot experiencing stomach pain.

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## The Korean Singing Humanoid (EveR-1):



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Moving on to humanoid research in some other countries, this robot is from South Korea. This one is named **EveR-1**

This robot made its debut in 2006.

This robot

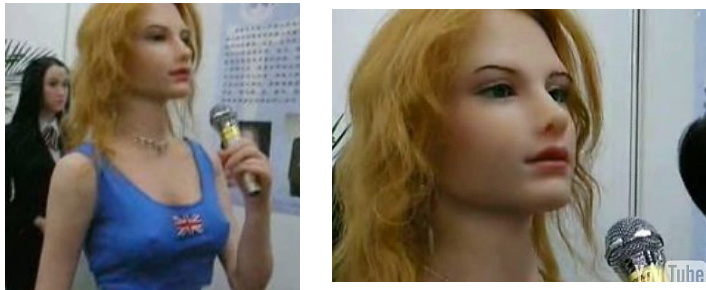
- is 5' 3" tall and weighs 110 pounds
- has a vocabulary of 400 words
- her lips move and her facial expression changes in sync with whatever she is saying or singing.

This robot was built by the Korea Institute for Advanced Technology. This one is also a torso humanoid like Actroid and Repilee

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## The Chinese Singing Humanoid (Dion):



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This is the Chinese humanoid named **Dion**

Her repertoire of lip movements and facial expressions is much more limited than that of the Japanese Actroid and the Korean EveR.

The robot sings and moves her lips as she sings.

I believe there are videos of this robot doing her thing on the internet.

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And This is the American Answer:



COURTESY BUENA VISTA PICTURES



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And this is the American answer to international humanoid challenge.

I suppose you recognize this humanoid.

This is actually a real human impersonating as a humanoid.

The real human here is

**Robin Williams**

from the movie

**Bicentennial Man**

that was based on the Isaac Asimov novel

**The Positronic Man**

More seriously, there is indeed humanoid research going on in the US. However, the focus of much of this research is on building smart heads — a contraption equipped with a couple of cameras that is supposed to examine a scene visually in much the same way as a human.

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## What Do the “Futurists” Have to Say About Robotic Intelligence

Let’s consider

### Ray Kurzweil

- Received the \$500,000 Lemelson-MIT Prize (2001)
- Received the 1999 National Medal of Technology
- Inducted into the National Inventors Hall of Fame (2002)
- And many other honors and awards

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Let’s see now look at what some very prominent people have to say about future of robotic intelligence.

Consider Ray Kurzweil

He is very well known. You could even call him famous.

As the slide shows, he received the National Medal of Technology in 1999 from President Clinton. He was inducted into the National Inventors Hall of Fame in 2002. The slide shows just three of the numerous awards and honors that have been bestowed on him.

Obviously, Mr. Kurzweil is NOT a lightweight by any stretch of imagination.



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## Ray Kurzweil Says:

- By the 2030s, the nonbiological portion of our intelligence will predominate
- By 2009, computers will disappear. Displays will be written directly onto our retinas by devices in our eyeglasses and contact lenses.
- Supercomputers will achieve one human brain capacity by 2010, and personal computers will do so by about 2020.

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Mr. Kurzweil has received a lot of attention lately for his claim that robotic intelligence will exceed human intelligence by the year 2030. Mr. Kurzweil uses the word “singularity” to describe the moment when this transition will take place. He has authored a book under that title that appears to be selling well.

The slide shows a couple of the other claims by Mr. Kurzweil. It is interesting to note that, according to Mr. Kurzweil, computers will write information directly onto our retinas in the very near future, obviating the need for computer displays. (If that were to happen, I suppose we will have to start wearing shades even indoors in order to protect our brains from this direct assault by computers.)

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But this is what The New York Times Wrote about Ray Kurzweil on November 24, 2006

*"Mr. Kurzweil, 58, who takes more than 150 vitamins and supplements a day, believes people will eventually live forever. Others know he has said that in 2045, man and machine will achieve "singularity," and humans will hold their breath for hours thanks to nanomachines in our bloodstreams."*

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As a side note on Mr. Kurzweil, I thought you might also like to see this report that appeared in a prominent newspaper:

The article from which I took this quote was on Mr. Kurzweil's claim that the software developed by his company was capable of analyzing the stock market trends with AI based tools and this analysis resulted in risk-free quick-returns on investments in stocks.

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Here is another futurist:  
Hans Moravec

- One of the founders of the CMU's famed Robotics Institute
- Research Professor at CMU
- Author of many books

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Let's now look at another famous futurist.

Hans Moravec is a very well known personality in academia and author of several books dealing with artificial intelligence.

He is also one of the founders of the Carnegie Mellon University's famous Robotics Institute.

He is currently a research professor at CMU

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## Hans Moravec says:

- ▣ Robots will emerge as their own species by 2040. They could replace us in every essential task and, in principle, operate our society increasingly well without us.
- ▣ No longer limited by the slow pace of human learning and even slower pace of biological evolution, intelligent machine will conduct its affairs on an ever faster, ever smaller scale, until coarse physical nature has been converted to fine-grained purposeful thought.

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Hans Moravec's prediction is not that different from Ray Kurzweil's. Professor Moravec says that robots will emerge as their own species by 2040.

Professor Moravec is convinced that robots would be able to replace humans in all conceivable tasks and operate our society without us.

Not only that, Professor Moravec believes that the robots will never be satisfied with the slow pace of biological evolution.

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## Let's Look at Another Celebrated Futurist: Marvin Minsky

- Needs no introduction for most people.
- But in case you are very, very young and have not heard of him:
  - a distinguished professor at MIT
  - considered to be a founder of AI
  - member of NAS, NAE
  - author of many books

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Let's now look at another celebrated personality: Marvin Minsky

Many people consider Professor Minsky to be the founder of the field of Artificial Intelligence. He has also been highly honored and many awards have been bestowed on him. He is a member of both the National Academy of Sciences and the National Academy of Engineering. These are considered to be two of the most prestigious organizations that only a select few are admitted into.

What I showed you for the previous two personalities are their current opinions.

What I am going to show you for Professor Minsky is a somewhat dated prediction made by him, but nonetheless worthy of examination because he occupied an important position in academia when he made those claims.

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## Marvin Minsky said:

- ▣ As quoted in a *Life* magazine article in 1970

*"In from three to eight years we will have a machine with the general intelligence of an average human being. I mean a machine that will be able to read Shakespeare, grease a car, play office politics, tell a joke, have a fight. At that point the machine will begin to educate itself with fantastic speed. In a few months it will be at genius level and a few months after that its powers will be incalculable."*

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It seems to me that the predictions made by Professor Minsky in 1970 sound very much like Mr. Kurzweil's predications today — especially when Professor Minsky talks about the future *incalculable powers* of the machines.

Professor Minsky also talks about the “machines educating themselves at fantastic speeds.” However, Professor Minsky does not care to tell us about the meaning of “educating oneself.”

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There are many such highly honored and highly accomplished individuals who seem to be convinced that someday, in the not too distant future, **robotic intelligence will exceed human intelligence.**

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The three people whose predictions I have presented are a representative set from a large number of such individuals out there — many of them highly accomplished, supposedly highly informed, and often highly influential.

All of these individuals hold the conviction that the robotic intelligence will exceed the human intelligence in the not too distant future.

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But There is one Basic Problem with all Such Predictions ....

- There does not exist a scientific definition for the notion of

INTELLIGENCE

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But there is one basic problem with all such predictions:

**There does NOT exist a scientific definition for the notion of INTELLIGENCE.**



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Every scientific constituency has its own definition of what is meant by intelligence

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As the slide says, every scientific community has its own definition of intelligence.

As you will soon see, it is almost like six blind men and the elephant when it comes to supplying a definition for intelligence.

You will find all definitions to be equally valid.

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## For Comparing the Definitions of Intelligence ...

□ Let's see what the following folks have to say:

- Evolutionary Psychologists
- Cognitive Psychologists
- Social/Cultural Psychologists
- Educational/Developmental Psychologists
- Computational Theorists

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Let's examine the definitions of intelligence as supplied by the following folks:

- Evolutionary Psychologists
- Cognitive Psychologists
- Social/Cultural Psychologists
- Educational/Developmental Psychologists
- and, finally, the Computational Theorists

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## Evolutionary Psychologists say:

- ... that intelligence has a genetic basis
- ... and that intelligence has evolved by natural selection related to solving important problems of the survival of the species and its reproductive mechanisms
- ... further implying that different evolutionary trajectories could result in different forms/types/categories of intelligence

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As you would expect, intelligence has a genetic basis for evolutionary psychologists.

For these folks, human intelligence has evolved through natural selection related to the survival of the species.

If we were allowed to extrapolate what the evolutionary psychologists say, different evolutionary trajectories would result in different forms of intelligence.

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## Cognitive Psychologists say:

- ... intelligence consists of “algorithms” that people use consciously or subconsciously to understand, diagnose, and solve problems in reasoning and perception

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Cognitive psychologists are close to my heart because their sense of what constitutes intelligence is similar to how computer scientists try to make machines behave intelligently.

As the slide says, intelligence for cognitive psychologists consists of algorithms that we use, consciously or subconsciously, for understanding and solving problems in reasoning and perception.

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## Social/Cultural Psychologists say:

- ... intelligence is defined in terms of the ability to achieve success in life in terms of one's personal standards, **within one's sociocultural context**.
- ... success is attained through a balance of analytical, creative, and practical abilities.
- As to what the above means, let's look at the examples on the next slide

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Recently, social/cultural psychologists have provided some radically new insights into what constitutes intelligence and how it works in humans.

This they have done by observing people in third world countries where many of the assumptions we implicitly make about intelligent behavior simply do not apply.

These folks say that the abilities that we call intelligence depend on the socio/cultural context in which we are expected to show those abilities.

What that means is that we may be able to exhibit what would be thought of as intelligent behavior in one socio/cultural context, but may be unable to show the same behavior in a different socio/cultural context.

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## For example:

- Brazilian street children are quite capable of doing the math required for survival in their street business but show little ability to do the same kind of math at school. (Carrahar et al. 1985)
- Women shoppers in California who had no difficulty in comparing product values at the supermarket were unable to carry out the same mathematical operations in paper-and-pencil tests. (Lave 1988)
- In another well-known study, skilled handicappers implicitly used a highly complex formula involving seven variables; the ability to do this successfully was unrelated to scores on intelligence tests. (Ceci and Liker 1986)

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This slide shows two of the several such observations made by social/cultural psychologists.

About the Brazilian street kids mentioned in the first bullet, note that their street survival could mean facing death if they fail to earn sufficient money.

Note also the interesting observation made on the California women shoppers.

## Developmental Psychologists say:

- As an infant grows, acquisition of "first proper intelligence" takes place between the ages of nine to twelve months with the development of coordination between means and ends and with the development of logic. (Piaget 1972)
- Developmental psychologists also differentiate between:
  - Crystallized intelligence (based on memory, experience)
  - Fluid intelligence (based on ability to find meaning in confusion and to be able to solve previously unseen problems)

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Let's now see what the developmental psychologists have to say. These folks are concerned primarily with when/how newborns and children first acquire what could pass for intelligence.

The developmental psychologists provide us great insights because, in order to measure intelligence in the newborns and children, they have to have measurable definitions for intelligence.

For Piaget, who founded the field of developmental psychology, intelligence meant recognizing relationships between means and ends, and engaging in logical thinking.

Logical thinking for Piaget did not mean adding 2 with 2 and saying the result is 4 — that's the type of logical thinking we do in sciences. For Piaget, logical thinking meant: Suppose I pour water out of a tall slender glass into a shallow bowl, when does a child know that the amount of water has not changed.

These folks make a distinction between **crystallized intelligence** — intelligence derived primarily from memory — and **fluid intelligence** — the sort of intelligence you need to solve previously unseen problems.

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## What do the Computational Theorists Have to Say about Intelligence:

- Main obsession: The Turing Test
- Briefly stated, TT boils down to:

If by acting and talking like a human, a computer can fool an **average** human judge into believing that it (the computer) is a human (**and do so at least 70% of the time within a time span of 5 minutes**), then the computer can be considered to be intelligent.

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Finally, let's see what computational theorists have to say about intelligence.

Computational theorists are mainly obsessed with the Turing test as a way to establish that a machine possesses human-like intelligence.

There are some very basic problems (philosophical, psychological, etc.) with the Turing test as stated in the slide.

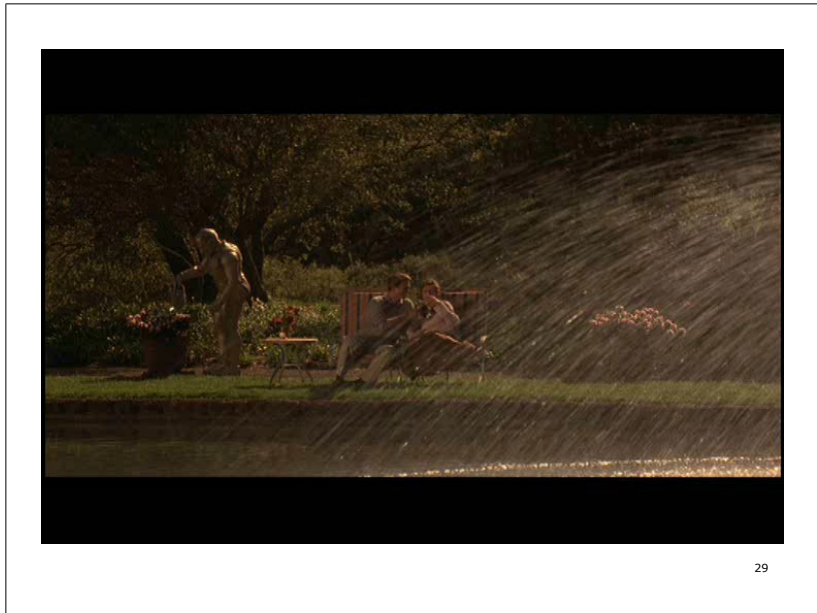
For a straightforward problem with the test, suppose you believe that integrity is an essential trait of the right kind of human intelligence. If a robot were to exhibit this trait, then it would not be able to lie. So in a Turing test, all you'd need to do would be to ask the robot if it is a machine.

Another interesting aspect of the test is the five minute time limit. I suppose even Turing believed that you might be able to construct a machine that would be smart enough to fool a human some of the time, but not all of the time.



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In the context of judging the intelligence of a machine by having a human converse with the machine, the following two-minute snippet from *THE BICENTENNIAL MAN* movie is telling.

The conversation you will see is between a man and a robot whose brain is based exclusively on rational logic.

Just before the scene I am about to play, Sam Neill has already told Andrew the Android about how humans reproduce, about sex, about courtship, and — this is most relevant to the scene you are about to see — about how men and women tell each other jokes to make the other person laugh.

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- I'll next examine what two highly regarded psychologists have to say about intelligence. I will quote

**Robert Sternberg** (Yale and now Tufts)  
**Howard Gardner** (Harvard)

- And then I'll do the same for two philosophers who have had much influence on Western thought:

**Baruch Spinoza**  
**John Dewey**

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Now that we have gone through what various scientific constituencies have to say about intelligence, let's now focus on a few specific individuals who have had a great impact on how we understand life today.

First our two contemporaries:

**Robert Sternberg** is the president of American Psychology Association. A former professor at Yale and now a Dean at Tufts.

**Howard Gardner** a very famous psychologist, a professor at Harvard. Has authored many books, most recently **Frames of Mind**.

Next two great philosophers from the past:

**Baruch Spinoza**, a founding ethicist of Western Civilization. He also laid the foundations of enlightenment and Biblical criticism. Lived in the middle part of the seventeenth century.

**John Dewey** is considered to be one of the most influential American philosophers. Did most of his work in the early part of the last century.

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## Robert Sternberg's Theory (1985):

- Human intelligence has three fundamental components:
  - Analytic (also called academic)
  - Creative
  - Practical
  
- Only the first is measured to any significant extent by mainstream intelligence tests.

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Robert Sternberg says that human intelligence has three more or less independent components: analytic, creative, and practical.

Most importantly, according to Sternberg, the mainstream intelligence tests measure only the analytical intelligence.

## Howard Gardner's Theory:

- Has posited the existence of multiple intelligences (there are at least eight)
- These include: logical, linguistic, spatial, musical, kinesthetic, naturalist, intra-personal, and inter-personal.

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Howard Gardner believes that there are at least eight different kinds of intelligence: logical, linguistic, spatial, musical, kinesthetic, naturalist, intra-personal, and inter-personal.

We all know people who are linguistically adept but have no sense of direction, or people who have great logical skills but are tone deaf.

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## What do the Philosophers have to Say About Intelligence

- Spinoza makes a distinction between:
  - the intelligence that resides in all of us taken collectively
  - the intelligence that resides in each of us individually

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What I find most interesting about Spinoza's ideas is the distinction he makes between the collective intelligence we exhibit when we operate in groups and the intelligence we exhibit as individuals.

Spinoza says that the intelligence we exhibit as individuals is bounded by our collective intelligence.

I believe that Spinoza also says that the attributes of collective intelligence we exhibit in groups cannot be predicted from our individual intelligences.

History has shown us repeatedly that people who are otherwise kind and generous as individuals are capable of turning into monsters when operating in the form of communities, tribes, and nations. I wonder if this is related to what Spinoza has to say about the individual and collective intelligences.

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## John Dewey tells us:

- Nothing is unchanging. Human beings are constantly changing; they are forever changing.
- Intelligence is the human instrument for adapting to, altering, and refining one's transaction with the environment.
- Intelligence ... is the result of attempting to overcome problematic, threatening, and unstable characteristics of experience.
- How intelligence is perceived is something that is constantly changing.

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Regarding John Dewey, if you enjoyed the emphasis your early schooling placed on the development of your creative impulses, you have no one but him to thank for.

John Dewey was a forceful proponent of the notion that early education needed to be democratic and that it needed to focus on the enhancement of individuality and creative impulses (as opposed to rote learning). There was a time in American history when some people genuinely believed in the elitist theory that children needed to be separated into two groups early on: one destined for higher learning and the other for vocational training.

To me what is most interesting about John Dewey's views is what is stated in the last bullet on the slide — how intelligence is perceived is something that is constantly changing.

What that implies is that intelligence is not a static concept. If I could take the liberty of extrapolating John Dewey, what was considered intelligent two thousand years ago may not be considered intelligent today.

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## The Big Question:

- Considering that there is **no agreed-upon single definition of intelligence**, how can some of the most honored minds in our midst go half-cocked and proclaim that robotic intelligence is about to take over human intelligence?

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Everything I have said so far leads to the BIG QUESTION stated on the slide.

Considering that every deep thinker, those from our past and those in our midst, has a different take on what constitutes intelligence, all we can say is that intelligence — like beauty, like passion, like emotions — is something that is not open to any meaningful analysis and quantification.

Again as with beauty, with emotions, with passions, and all things of that sort, we recognize intelligence when we encounter it, but we can never say precisely what it is.

We may capture many different facets of intelligence in different ways, but probably we will never be able to comprehend it in its entirety.

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## A Possible Answer:

- In the truly grand spectacle of the Mother Nature that we all spring from, **we are all merely children.**
- **In relation to the enormity of Nature,** a 50 year old man, no matter what the pedestal that he is placed on either through genuine recognition or through self-promotion, is as much a child as a 5 year old.

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This slide presents a possible answer to the BIG QUESTION stated on the previous slide.

As the slide states, in the grand spectacle of the Mother Nature, we are all merely children. That applies as much to a five year old as it does to a fifty, sixty, or seventy year old.

The insecurities, the ego, and the general neediness of a grown-up adult may drive him/her to claim to understand things that he/she truly does not. But the Mother Nature in all its essences is probably as beyond reckoning to him/her as it has always been to all from time immemorial.

I do not mean to belittle the great advances we have made in science and technology. But science is still very young. It is highly likely that what we still do not know far exceeds what we already know.

It is probably much too early for us to make judgements and predictions of the sort that our much celebrated futurists engage in with great abandon.



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## Possible Answer (cont.)

- A 50 year old man has as much a need for a security blanket as a 5 year old.
- The only difference is that a 5 year old's is a physical object, whereas a 50 year old's is a mental construct, a psychological crutch.

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To continue with my answer to the BIG QUESTION, this slide reemphasizes the fact that it is probably the need for recognition that causes some otherwise great people to make indefensible pronouncements about the future.

The tragedy is that since these individuals often occupy important positions in the society, people want to believe in them. To me it is such a societal waste when you have these believers running around with idiotic visions of how the future will unfold for us.

## Moving On to the Positive

- Where does robotic intelligence stand today?
- What are the most complex experiments that can be carried out today to demonstrate robotic intelligence?

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Let's now talk about robotic intelligence.

Despite the fact that the human intelligence is still largely a mystery to us, the last fifty years have witnessed the emergence of a legitimate area of research and development — robotic intelligence.

To me, robotic intelligence merely represents a continued progression in the state of automation in our industrial society. (It is interesting to reflect on the historical fact that the arrow of automation has never pointed downwards. It may have remained flat during difficult periods of our history, but societies have never become “de-automated.”)

If an affordable and dependable machine can be made to vacuum a house and do the kitchen dishes, that frees us more time to engage in things that are more satisfying.

But, at the same time, if we have succeeded in devising a machine to engage in a task that seemed too difficult earlier (difficult for a given level of affordability), that does not mean that we have suddenly unlocked one more mystery of human intelligence.

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## RI vs. AI

- ❑ Robotic intelligence usually implies a smart automaton with mechanical capabilities
- ❑ Artificial Intelligence can be thought as a more general version of the “intelligence” part of RI.
- ❑ Many of the ideas that get developed under the more general label of AI find applications in RI.

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Robotic intelligence (RI) can be considered to be a sub-area of the much broader “Artificial Intelligence” (AI).

RI usually implies a combination of electro-mechanical and computing capabilities. On the other hand, AI deals mostly with how to translate into computer programs some of our own cognitive capabilities.

But, again, just because we have figured out how to get a computer to add 2 and 2 does not mean we have unlocked the mystery of human intelligence. All it means is that we have figured out how to translate a particular goal into the instructions that a machine can understand.

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## Some Popular Research Themes in AI:

- case-based reasoning
- reasoning under uncertainty
- neural networks
- combinatorial games
- multi-agent planning
- scheduling
- intelligent tutoring
- data mining
- natural language understanding and translation

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This slide shows a sampling of the topics that are studied under AI.

**Case-based Reasoning:** means solving a problem by using reasoning that is similar to what was used earlier in a different context.

**Reasoning Under Uncertainty:** means taking into account noise and other forms of uncertainty by statistical modeling and other means.

**Neural Networks:** A neural network is an interconnected group of simple neuron-like circuit elements that have been shown capable of data classification and pattern recognition.

**Combinatorial Games:** deals with algorithms for two-player games like chess, checkers, etc.

**Planning and Scheduling:** is about the realization of actions to bring about a certain goal state in solving a problem.

**Intelligent Tutoring:** refers to computer systems that are able to provide direct feedback to a student engaged in learning something.

**Data Mining:** refers to sifting through large amounts of data and picking out the relevant information.

**Natural Language Processing**

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## Some Popular Themes in Computer Vision and Robotics:

- real-time visual servoing and object tracking
- content-based image retrieval from image databases
- distributed computer vision with sensor networks
- face recognition and biometrics
- machine learning as applied to computer vision problems
- map building and navigation
- computer vision for image-guided surgery <sup>41</sup>

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I will now focus exclusively on computer vision and robotics — since those are my research areas.

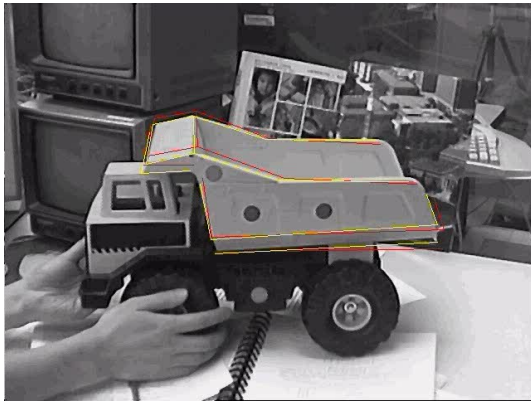
This slide lists some of the more popular research topics in computer vision and robotics.

The bullets shown in red are those in which my laboratory has made significant contributions.

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## Model-based Tracking (video)



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I will now show a short video of a computer vision system tracking a complex object even in the presence of obscuration.

The computer has been provided with a model of the object it is tracking.

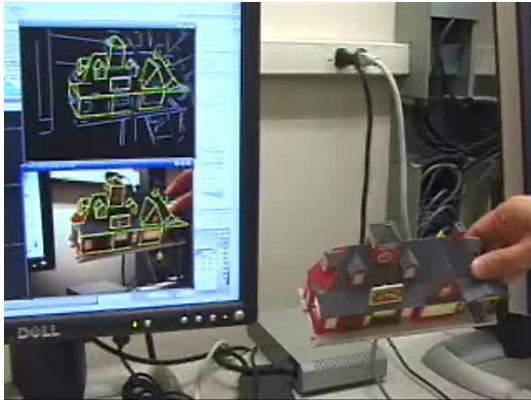
The model is extremely simple. It is called a wireframe model. It consists of some straight-line features on the object and the 3D coordinates of the end points of those lines.

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## Model-based Tracking (video)



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This video is based on the same computer program that was used in the previous video. The difference is that the object being tracked now is much more complex.

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## Visual Servoing for Smart Robotics

- The goal here is to develop a vision-guided robotic system that can operate on a moving assembly line.
- Expected to eliminate the need for the very expensive stop stations in assembly lines.
- Represents the next generation of vision-guided robots.



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I will now show an application of this sort of computer vision in what is considered to be the robotics of the future.

You see, if you walk into a automobile factory today, you will see many robots in action. But all these robots can only assemble parts on an automobile frame when the frame is stationary.

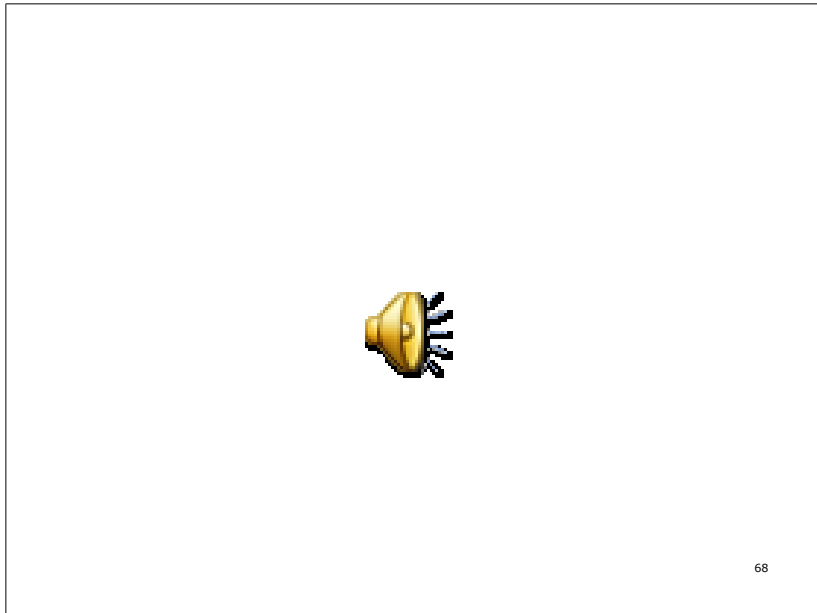
In other words, the robots as used today are unable to interact with an object that is moving in space. We want the robots of the future to assemble parts on a moving assembly line.

That this can be done is demonstrated by the video I will show next.



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I will end this talk by playing a mix of Vivaldi's Four Seasons (Summer) and a pop tune from The Animals. The pop tune is "Please don't let me be misunderstood."

As you listen to this recording, in your own head you will have no trouble keeping track of the individual pieces of music.

Today, we can't even begin to figure out how to program a computer to do the same.

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## But What About the Title of this Talk:

While obviously a cheap hook, it is nevertheless intended to convey the possibility that it is our emotions, our passions, our innate desires --- all ingredients of our sexuality -- that are the defining elements of our consciousness and, through consciousness, our intelligence.

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## But What About the Title of this Presentation ....

While obviously a cheap hook, it is nevertheless intended to convey the possibility that it is our emotions, our passions, our innate desires — all ingredients of our sexuality — that are the defining elements of our consciousness and, through consciousness, our intelligence.

*The End*

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## **Acknowledgments**

Thanks go to my friend and colleague Professor Johnny Park for his help with the formatting of this presentation.

Many thanks go to various individuals, some from amongst those who have attended this talk in the past, for their questions and comments. The version of this talk that you are looking at incorporates changes that resulted from the feedback.

Finally, many thanks go to Professor Noriko Nagata for pointing out that, despite my claims to the contrary, the previous version of this PDF file still had several typographical errors in the narration that accompanies the slides. Hopefully this new version, posted in August 2009, is free of errors. Professor Nagata's research is unique in as much as it tries to blend computer science with perspectives drawn from human psychology and with what we know about human emotionality. I have much enjoyed the conversations with her during her mini-sabbatical at Purdue during summer/fall of 2009.