MARTIN PHILIPS is an ambitious radiologist working at the Hobson University Medical Center in New York. He is working together with William Michaels, a brilliant computer scientist who completed his PhD at MIT at the age of nineteen and went on to become the head of a newly created Division of Artificial Intelligence. One morning Michaels visits Philips with a special surprise.

Philips flipped open the case and pulled out the cassette. It wasn’t a musical recording. It was a computer program.

“How far did we get?” asked Philips almost in a whisper.

“It’s the whole thing,” said Michaels.

“No!” said the incredulous radiologist.

“You know the last material you gave me? It worked like a charm. It solved the problem of density and boundary interpretation. This program incorporates everything you’ve included in all your flow sheets. It will read any skull X ray you give it, provided you put it into that piece of equipment over there.” Michaels pointed to the back of Philips’ office. There on top of Philips’ worktable was a TV-sized electrical apparatus. It was obvious that it was built as a prototype rather than production model.

“I don’t believe it,” said Philips, afraid that Michaels was teasing him again.

“Neither do we,” admitted Michaels. “Everything just suddenly fell together.” He walked over and patted the top of the computer unit. “All the work you’d done in breaking down the problem-solving and pattern recognition aspects of radiology not only made it apparent we needed new hardware but also suggested the way to design it. This is it.”

“Looks simple from outside.”

“As usual, appearances are deceptive,” said Michaels. “The innards of this unit are going to revolutionize the computer world.”

“And think of what it’s going to do to the field of radiology if it can really read X rays,” said Martin.

“It will read them,” said Michaels, “but there could still be bugs in the program.”

Philips feeds film after film into RadRead as Michaels has called his masterpiece, and is stunned by the program’s baffling performance.
As soon as the typewriter ceased its rapid staccato, Philips tore off the report. He read it with Denise looking over his shoulder.

“Amazing!” said Philips when he’d finished. “The computer certainly agrees with our impression. And it remembered that it had seen the same density pattern on Lisa Marino’s X ray, and on top of that it asks me to tell it what this density variation is! This thing is goddamn amazing. It wants to learn! It’s so human it scares me.”

Philips grabbed the phone and punched out Michaels’ home number. When Michaels answered, he told him he had not been able to follow up on Marino, but was going to get definitive films in the morning. He added that the computer had actually asked him to tell it what the abnormal density changes were.

“Remember,” said Michaels, “the program approaches radiology the same way you do. It’s your techniques that it utilizes.”

“Yeah, but it’s already better than me. It picked up density variation when I didn’t see it. If it uses my techniques, how do you explain that?”

“Easy. Remember, the computer digitizes the image into a two-hundred-fifty-six by two-hundred-fifty-six grid of pixel points with gray values between zero and two hundred. When we tested you, you only could differentiate gray values of zero to fifty. Obviously the machine is more sensitive.”

No, you are not reading the script of the Hollywood movie based on this thesis. The conversations are taken from *Brain*, written by Robin Cook, the godfather of the medical thriller, in 1979. It’s probably the only bestseller about computers reading radiographs ever written.

This thesis is another book about computers reading radiographs. But I’m afraid it will never become a bestseller because the plot is not so spectacular. Unlike William Michaels, I will not turn out to be a modern Frankenstein who kills young beautiful women, puts their brains in cylinders with cerebrospinal fluid and somehow hooks up a keyboard and monitor to the floating gray matter. Instead I used meagre Intel Pentium processors and this comes at a price: the performance of my programs is nowhere near that of RadRead. Nevermind the blatant nonsense it contains, *Brain* has a point here: if we unravel the mechanisms that underlie visual perception in living systems, we may be able to program computers to display similarly impressive performance.

In fact, this idea attracted me to this field, to the research group I have been working in, and to the topic of my PhD project. I’ve learned many things about image processing, with techniques that are firmly based in physics and mathematics and that are already powerful enough to be used successfully in real applications. On the other hand, I have also arrived at the opinion that many expectations and predictions about the capabilities of computer vision and artificial intelligence systems, that must have inspired Robin Cook to write his *Brain*, are totally unrealistic. To be a little bit more precise, articles from the 1970s on computer analysis of radiographs talked about automating the chest exam. This did not happen in the past thirty years, and I do not believe it will happen in the next thirty years.
I am aware that I just tried to predict the future. And predicting the future is tricky business. Consider the following prediction from the famous English logician Alan Turing. He put forward a practical definition of a thinking machine. An interrogator is asking questions to someone in a different room. The conversation is only displayed on a computer monitor. If the interrogator cannot deduce whether the answers are given by a person or a computer imitating a person, the computer can be considered a thinking machine. In an article that appeared in 1950 \cite{turing} Turing states:

\begin{quote}
“\hspace{0.05in}I believe that in about fifty years’ time it will be possible to programme computers, with a storage capacity of about $10^9$, to make them play the imitation game so well that an average interrogator will not have more than 70 percent chance of making the right identification after five minutes of questioning.”
\end{quote}

Turing was wrong, but the amazing thing about this quotation is that the casually made second prediction, about the existence of computers with a storage capacity in the order of $10^9$ around the year 2000, is correct! This is usually referred to as Moore’s Law, formulated thirty years ago by Intels co-founder Gordon Moore. He stated that computer processing power could be doubled every 18 to 24 months. The chip industry has been able to live up to this incredible rate of progress ever since and is expected to continue to do so for at least the next decade or so. I believe that Moore’s Law is the prime explanation for the progress made in computer vision and, more specifically, computer-aided diagnosis. Obviously, the efforts of image processing researchers were essential too. There is now a commercial product available that assists radiologists in reading mammograms, the \texttt{ImageChecker} from R2 Technology, Los Altos, CA. I believe such products will become available for chest radiography as well, and that this will increase the effectiveness and efficiency of medical care. And I hope that the research described in this thesis will contribute to this.