### AESS MEETINGS & CONFERENCES

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| 3-10 March 2007 | 2007 IEEE Aerospace Conference                                            | Big Sky, MT   | D. Wooner, (818) 732-8228 (510) 545-7221 F dwooner@ieee.org  
http://www.aeroconf.org/ |
mjamsahid@wisc.edu, or http:// engineering.utexas.edu/2007/eesosse  |
| 17-20 April 2007 | IEEE Radar Conference 2007                                               | Boston, MA    | info@radar2007.org  
www.radar2007.org |
| April 2007   | AESS BoG Meeting                                                        | Boston, MA    | T. Saunders, (503) 386-6349  
tsanders@monkey.com |
http://www.spacecom.gc.nasa.gov/icnsconf  |
gs@eager.com  
http://www.elektrornabor.spb.ru |
| 4-8 June 2007 | 2007 International Waveform Diversity & Design Conference              | Pisa, Italy   | P. Woodard, (315) 310-2644  
paul.woodard@ria.md  
http://www.waveformdiversity.org  |
jlhearn.ross@nrao.gov |
| 15-18 October 2007 | Radar 2007 The International Conference on Radar Systems               | Edinburgh, UK | I. Binerjer, +44 (0) 1438 765 699  
+44 (0) 1438 765 305 F  
ebinderje@theiet.org  
http://conferences.theiet.org/radar07/  |
| October 2007 | AESS BoG Meeting                                                        | Edinburgh, UK | T. Saunders, (503) 386-6349  
tsanders@monkey.com  
http://www.aessto achieve.  |
| 4-5 November 2006 | International Workshop on Haptic Audio Visual Environments and their Applications (HAVE 2006) | Ottawa, Canada | E. Binerjer, +44 (0) 1438 765 699  
+44 (0) 1438 765 305 F  
ebinderje@theiet.org  
http://www advocat eouve.c  |
| 22 November 2006 | IEEE International Conference on Recent Advances in Space Technologies | London, UK    | E. Binerjer, +44 (0) 1438 765 699  
+44 (0) 1438 765 305 F  
ebinderje@theiet.org  
http://www.aessto achieve.  |

### OTHER SOCIETY MEETINGS OF AESS INTEREST

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| 20-23 March 2007 | 2007 International Conference on Systems Engineering and Modeling (ICSEM) | Haifa, Israel | V. Behar, +972 2 829 4445  
+972 2 829 4448 F  
dori.ie.technion.ac.il  
http://dori2.technion.ac.il/ICSEM07/  |
+90-212-6628551 F  
ras2007@ras.org.tr  
www.rast.org.tr  |
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Making Weirdness Work:  
Quantum Information and Computation

Information is something that can be encoded in the state of a physical system, and a computation is a task that can be performed with a physically realizable device. Therefore, since the physical world is fundamentally quantum mechanical, the foundations of information theory and computer science should be sought in quantum physics. In fact, quantum information has weird properties that contrast sharply with the familiar properties of classical information. A quantum computer — a new type of machine that exploits the quantum properties of information — could perform certain types of calculations far more efficiently than any foreseeable classical computer. To build a functional quantum computer will be an enormous technical challenge. New methods for quantum error correction are being developed that can help to prevent a quantum computer from crashing.

Preventing Damage by Hidden Objects in Vegetation

The paper presents the experimental radar-based sensor to operate in environment with vegetation cover for detection and discrimination there the small-sized invisible dielectric and metallic objects. This sensor constitutes a vehicle-housed emergency system for surveillance of area with vegetation ahead on the path of moving vehicle to prevent its contact with hidden objects. The emergency system functioning in basically implemented by real-time electromagnetic imaging of the scene of interest and its following image processing to enhance the target responses. The developed and tested experimental radar techniques are under consideration. The results of experimental examinations in field are presented and discussed.

Security Systems Research and Testing Laboratory at Edith Cowan University

The testing and evaluation of sophisticated security systems has remained in the domain of governments in national facilities and the commercial security industry through manufacturers and engineering consultants. As well, the production of testing protocols and industry standards has been developed by national organisations, professional security, and engineering bodies in the appropriate security fields.

The Security Systems Research and Testing Laboratory in the School of Engineering and Mathematics at Edith Cowan University (ECU), Perth, Western Australia has commenced operations in research, testing, and evaluation of security systems. This paper will describe the first year of operation of the Security Systems Research and Testing Laboratory, and will describe the role that testing and evaluation of security systems plays in the education and training of Security Science graduates, as well as the benefits that the Laboratory brings to the security industry through its testing programme.

Strategy of GPR Searching for Low Radar Contrast Plastic Pipes in Ground

The results of computer simulation of pulse signal scattering by a plastic pipe buried in the ground as well as simulation results of Ground Penetrating Radar (GPR) image of ground-filled trenches have been represented in the work. The “skeleton diagram” of a trench image has been developed. The strategy of GPR searching for low radar contrast plastic pipes in ground (in back-filled trenches) has been considered on the basis of indirect criterion which is the existence of a trench containing buried pipes.
Making Weirdness Work:
Quantum Information and Computation

John Preskill
California Institute of Technology

ABSTRACT

Information is something that can be encoded in the state of a physical system, and a computation is a task that can be performed with a physically realizable device. Therefore, since the physical world is fundamentally quantum mechanical, the foundations of information theory and computer science should be sought in quantum physics. In fact, quantum information has weird properties that contrast sharply with the familiar properties of classical information. A quantum computer — a new type of machine that exploits the quantum properties of information — could perform certain types of calculations far more efficiently than any foreseeable classical computer. To build a functional quantum computer will be an enormous technical challenge. New methods for quantum error correction are being developed that can help to prevent a quantum computer from crashing.

THE FUTURE OF INFORMATION TECHNOLOGY

You are probably aware that we are at the dawn of a new millennium, and as we look back at the 20th century, one of the most notable achievements of our civilization has been the development of our information technology. I think that my laptop computer is a pretty hot machine. But surely by, say, the end of the 21st century, the information technology that impresses us so much today will have been far surpassed by new technology that we cannot even imagine. Even so, I intend to speculate about the future of information technology.

This sort of projection of the future of technology is a task fraught with danger. Here is one cautionary tale. We recently celebrated the 50th anniversary of the ENIAC, which many regard as the first electronic digital computer. It is interesting to see what people were saying back in the 1940s about the future of electronic computing. Following is a quote from Popular Mechanics that appeared in 1949:

“Where a calculator on the ENIAC is equipped with 18,000 vacuum tubes and weighs 30 tons, computers in the future may have only 1,000 vacuum tubes and perhaps only weigh one and a half tons.” In fact, the computing power of the ENIAC is roughly equivalent to what is in a digital watch, and we have had digital watches since the 1970s. So the visionary who said this evidently was not thinking big enough or small enough.

No one can accurately predict the future of technology; that’s a given. And aside from that, I am particularly ill equipped for this task. I am a theoretical physicist, not an
engineer and I am not particularly knowledgable about how computers work. But a physicist knows without hesitation that the crowning intellectual achievement of the 20th century has been the discovery of the quantum theory, and it is natural to wonder how the development of quantum theory in the 20th century will impact the technology of the 21st century.

A physicist knows that, whatever information might be, it is something that can be encoded and stored in the state of some physical system, like the pages of a book, or the sectors of a hard disk. But we also know that all physical systems are fundamentally quantum mechanical systems. So information is something that can be encoded in a quantum state. The question addressed here is: Can the computers of the future better exploit the quantum properties of information, to perform tasks that are beyond what can conceivably be achieved with conventional silicon-based information technology?

CLASSICAL AND QUANTUM BITS

To get started, we’ll need to recall some basic facts about information. All (classical) information can be reduced to elementary units, what we call bits. Each bit is a yes or a no, which we may represent as the number 0 or the number 1. Anyone who has played the game 20 questions knows that much information can be conveyed by yes/no answers. A highly skilled player, by asking 20 questions, could in principle distinguish about 1,000,000 different objects. And if we are willing to allow more questions, in principle any number of objects could be distinguished. So we say that any amount of information can be encoded in the yes/no answers.

I like to visualize a bit as an object, let’s say a ball, that can be either one of two colors, let’s say either red or green. Bits are valuable, and we can store a ball for safekeeping by sealing it up inside a box. Then if we open the box later on, the color of the ball that pops out is the same as the color that we put in; we can recover our bit and read it.

But in quantum theory, the elementary unit of information is something rather different from the classical bit — I’ll call it a quantum bit, or a “qubit” for short. We may think of a quantum bit as a box with a ball stored inside, but in this case, we can open the box through either one of two doors, door 1 or door 2. To an experimental physicist, the two doors correspond to two different ways to measure the quantum state of an atom, or of a particle of light, but let’s not worry about that, we’ll just think of it as a box with two doors.

Suppose that we put a red or a green ball into the box, through either door 1 or door 2, close the door, and then open the same door again. The color of the ball that comes out is the same as the color that we put in, just as for a classical bit. But suppose that we put the ball into door number 1, and then we open door number 2. Then the color of the ball that comes out doesn’t have anything to do with what we put in, the color is completely random — 50% of the time it will be red and 50% of the time it will be green. If we open the wrong door, we can’t read the information that was put into the box.

HIDDEN INFORMATION

We have now seen one way in which quantum information, information encoded in qubits, is different than classical information, information encoded in bits. You can’t read quantum information unless you open the right door. But there is a more interesting difference between classical and quantum information, and to appreciate it, we’ll need to suppose that we have two boxes. The boxes can be far apart. One is at Caltech in Pasadena, and the other is in the custody of a friend who lives in the Andromeda galaxy. These boxes have some peculiar properties. First, if I open my box here in Pasadena, either through door 1 or door 2, the color of the ball that comes out is completely random. And the same is true for my friend in Andromeda. So when either one of us opens his box, through either door, we don’t get any information; we don’t find out anything about what is inside. That’s funny . . . we have two boxes so we should have been able to store two bits of information. How is that information encoded? Where is it hiding?

The answer is that the information is contained in correlations between what happens when I open a box in Pasadena and what happens when my friend opens a box in Andromeda. If I open my box through door number 1, I might find a red ball or I might find a green ball. But if I find a green ball, then if my friend also opens door number 1 on his box, he finds a green ball, too. And if I find a red ball, he always finds a red ball. Same thing if I open door number 2 and he opens door number 2 — we are guaranteed to find balls of the same color. What he finds is perfectly correlated with what I find if we open the same door.

There are several different ways in which what happens when we open a box in Pasadena can be correlated with what happens when we open a box in Andromeda, and we have chosen one of those ways — that’s information. But in this case, there is no way to get access to any of the information, no way to read it, just by making observations in Pasadena or Andromeda. Instead, the information is spread out in a very nonlocal way, shared equally in a sense, between the box in Pasadena and the box in Andromeda. This property of quantum information, that it can be encoded nonlocally, is what we call quantum entanglement. It is the crucial way in which quantum information is different than classical information [1], and it is what underlies much of what I want to discuss herein.

But not everyone is so impressed by these correlations. Correlations are not really so exotic; we encounter them all the time in everyday life. For example, I have a friend who, on any given day, decides at random to wear either red socks or green socks. (You may think my friend is rather eccentric, but among physicists he is considered quite normal.) Anyway, I can trust my friend to always wear two socks of the same color; he is very fastidious about that. So his socks are perfectly correlated. That means that, as soon as I see one of his feet and notice that he is wearing a red sock on that foot, I know for sure before I even look that there is a red sock on the other foot. And if I see a green sock on one foot, I know for sure that there is a green sock on the other foot, even without looking. So correlations
are not at all unusual. On the one hand my friend always wears two socks of the same color, and on the other hand when we open our two quantum boxes, each through the same door, we always find two balls of the same color. Is there really any fundamental difference between these two things? Aren't the boxes just like the socks?

THREE QUANTUM BOXES

In fact, I want to argue that there is a profound difference between the boxes and the socks. To explain why, it will be helpful to consider an even more peculiar friend of mine, one with three feet. This fellow also decides at random every day how to wear his socks, but he always wears an even number of red socks (either 0 or 2) and an odd number of green sock (1 or 3). I know him well, and I trust my friend; he never wears one red sock and never wears three red socks. That means that once I have seen two of his feet, I know with certainty before I even look, what color sock is on the third foot. If I see a red sock and a green sock, the third sock must be red. If I see two green socks or two red socks, the third sock must be green.

Now I want to consider an analogous situation with quantum boxes instead of socks [2]. We have three boxes. And suppose that we decide to open door number 2 of one of the boxes, and door number 1 of the other two boxes. Every time we try this, we find that the number of red balls is even (0 or 2); we never find one red ball or three red balls. I have tried this a million times, so I am sure that it’s true. Trust me.

This is interesting, because suppose that I want to know what will happen when I open the third box, either through door 1 or door 2. I can find out ahead of time, before I open that box, by opening the first two boxes. Let’s say I am interested in knowing what will happen when I open door number 1 on the third box. I can open door number 1 of the first box and door 2 of the second box, and suppose that I find one green ball and one red ball. Then I know for sure that I will find a red ball when I open door 1 of the third box. Or if I would like to know what will happen when I open door number 2 on the third box, I first open door number 1 on the first two boxes. If I find two green balls, I am sure to find a green ball when I open door number 2 of the third box.

It could be that these boxes are very far apart. Maybe one is in New York, one in Chicago, and one in Pasadena. Well, it seems obvious that opening boxes in New York and Chicago cannot have any influence on what happens when we open a box in Pasadena. So a reasonable person would say that the boxes are like socks. When I look at two of my friend’s feet and see a red sock and a green sock, I don’t think that I made his third sock turn red by looking at the first two socks. I just think that I found out enough about what socks he is wearing today to know that the third sock is red. He had a red sock on that foot all along, but I didn’t know it until I looked at the first two feet. So naturally, we assume that it is the same for the quantum boxes. Opening the first two boxes did not change anything inside the third box; it just gave us enough information to figure out what was in the third box all along.

All right, now let’s try something new. What will happen if we open door number 2 on all three boxes? We haven’t tried this before, so we don’t really know. But let’s try to use some theory. Let’s see if we can make a prediction about what will happen before we open the boxes. That will make the experiment more fun.

How are we going to make a prediction? I’ll reason this way: Another thing we haven’t tried is opening door number 1 on all three boxes, so I don’t know what would happen if we did that. But let’s make an assumption. Let’s suppose that if we open door number 1 on all three boxes, we’ll find three red balls. It’s just a hypothesis, but let’s assume this. If that’s the case, I can tell you for sure what will happen if we open door number 2 of any of the boxes. You remember, we know for sure that if we open door number 2 on one box, and door number 1 on the other two, we always find an even number of red balls. There is no doubt about that; we have checked it a million times. So, if we make our assumption about what happens when we open door 1 on all the boxes, What can we say about what happens when we open door 2 on, say, the first box? Well, since we find two red balls when we open door 1 of the second and third boxes, we know for sure that we’ll have to find a green ball when we open door 2 of the first box. Similarly, we have to find a green ball if we open door number 2 of the second box, because we find two red balls when we open door 1 on the first and third boxes. By the same argument, we have to find a green ball when we open door 2 of the third box. So from what we already know about the boxes, we can deduce that if we would find three red balls when we open door 1 of all three boxes, we must find three green balls when we open door 2 of all three boxes.

<table>
<thead>
<tr>
<th>Open Door 1</th>
<th>Open Door 2</th>
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<tbody>
<tr>
<td>Red Red Red</td>
<td>Grn Grn Grn</td>
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<tr>
<td>Red Red Grn</td>
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<td>Grn Grn Grn</td>
<td>Grn Grn Grn</td>
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</table>
Fig. 3. A quantum correlation among three boxes

Okay. The only thing is that we don’t really know what will happen when we open door number 1 of all three boxes; we just assumed we would find three red balls, and maybe that’s not true. But we can make a list of all the things that we could conceivably find were we to open door 1 on all three boxes. There are altogether eight possibilities, and here (in the first column) is the list (previous page, lower right):

Now, for each of these eight possibilities, we can use the same reasoning that I just described to infer what will happen if we open door number 2 on all the boxes, obtaining the list in the second column. And we find something interesting. For each of the eight possibilities for what could happen when we open door number 1 on all the boxes, we conclude that when we open door number 2 on all of them the number of red balls must be even — it can be 0 or 2, but it is never 1 or 3. So, it turns out that we really can make a prediction.

Let’s review what we’ve done. We have three boxes. And we know for sure that if we open door number 2 on one box and open door 1 on the other two, we always find an even number of red balls. No doubt about it; we’ve checked it a million times. Now we have been able to use simple logic to infer what must happen if we open door number 2 on all three boxes. We concluded that we must find an even number of red balls. Does our theory work?

In practice, an experiment with three quantum boxes is hard to do, but quantum mechanics makes a firm prediction about what we would find, a prediction for which ample experimental confirmation has been found in other related contexts. The result is rather shocking. Every time we open door 2 of all the boxes, we find an odd number of red balls, just the opposite of what we have just inferred!

If we review our reasoning to figure out where we went wrong, there seems to be only one place where we could have tripped up. We made the eminently reasonable assumption that the act of opening a box in New York and opening a box in Chicago could have no influence on the contents of a box in Pasadena. That’s certainly how it works for socks. But our “experiment” has shown that it doesn’t work that way for boxes. The boxes are not like the boxes. The experimental evidence has left us with no choice but to conclude that opening two of the boxes doesn’t just tell us what was in the third box all along; opening those boxes actually shapes what we will find when we open the third box. Hence there is a

Fig. 4. Boxes are not like soxes

Fig. 5. Quantum information cannot be copied perfectly

strange kind of nonlocality built into the foundations of quantum physics.\(^1\)

Not everyone is happy about this. One who was unhappy was Albert Einstein. He derived these nonlocal correlations between boxes as “spooky action at a distance” (except he said it in German). Einstein argued from this syllogism:

- A. I am Albert Einstein.
- B. I do not understand quantum mechanics.
- C. Quantum mechanics is wrong.

Actually, it is a strong argument. But we have been living with quantum mechanics for over seventy years now, and we still can’t find anything wrong with it. So it seems that it doesn’t really matter whether Einstein liked it or not, we have

\(^1\)But it is important to understand that this “nonlocality” does not enable us to send any message to a remote location faster than a light signal could travel there.
to accept that this weird nonlocality is an essential part of the description of Nature.

The human mind does not seem to be well equipped to grasp this aspect of Nature, and so we speak of the weirdness of quantum theory. Some people think that weirdness is ugly, but I don’t really think so. If Nature is weird, so be it, and let’s try to get used to it. But we can also go a step further, and see if we can put the weirdness to work. Does quantum weirdness enable us to perform tasks that would be impossible in a less weird world?

QUANTUM COPYING

As we search for ways to exploit the weird properties of quantum information, a good place to start is to think about copying information. How would a quantum copy machine operate? Suppose we have a quantum box, and I happen to have put a ball inside through door 2. The copier looks at the box and builds a second box. Now if we open both boxes, the original and the copy, through door number 2, we will find balls of the same color. And if I have put a ball in the original box through door number 1, then when I open both the original and the copy through door number 1, I will find balls of the same color.

But there is no such machine. The trouble is that to copy what is inside, the copier needs to open the box. But it has no way of knowing whether I put my ball in door 1 or door 2. It might guess right, and open the correct door, and then it can make a good copy. But if it guesses wrong and opens the wrong door, it will damage the information that I stored in the box, and it won’t be able to copy it faithfully. Quantum information cannot be copied [3].

This is disconcerting. Sometimes it is useful to copy information. On the other hand, sometimes it might be a good feature if information cannot be copied. For example, were we to carry quantum dollar bills, we would not have to worry about counterfeiters. Well, I don’t know what kind of money people will be carrying around in their pockets one hundred years from now; I don’t even know if they’ll have pockets. But one thing I am sure about. Even at the end of the 21st century, humans are going to want to keep secrets. That we can’t copy quantum information might be a good thing, if it enables us to build a quantum telephone that cannot be tapped [4].

You see, I have a friend named Alice, and Alice is very anxious to place a very private phone call to a man named Bob. But Alice has a very nosy friend named Eve, and Eve is habitually listening in on the extension. Alice needs to find a way of calling Bob where she can be sure that Eve is not eavesdropping. Obviously, Alice and Bob should use some sort of code. But it happens that Eve, in addition to being very nosy, is also extremely smart. And she likes nothing better than breaking codes — she absolutely revels in code-breaking. Alice is not at all confident that she is smart enough to think up a code that Eve cannot break.

But Alice knows that if she only had a string of random numbers, and she could send those random numbers to Bob, then Alice could use the random number as a key to code her message, and Bob could use the key for decoding. Then if Eve were to intercept the message, it would be completely random junk, and there would be no way for Eve to decode it. That is, there would be no way for Eve to decode the message unless she had the key. So the problem that Alice and Bob need to solve is: How can Alice send the random key to Bob, and be assured that there is no way for Eve to have intercepted the key?

Let’s see how quantum information can be used to solve this problem. Alice first assembles some random bits — balls that are either red or green. Then she gets some boxes, and decides at random to put each ball into either door 1 or door 2 of the corresponding box. She seals the boxes shut, and then sends them to Bob. Bob does not know which door Alice used on each of the boxes. But he decides at random to open each box through door 1 or door 2. Now it will happen by chance that about half the time, Bob will open the same door that Alice used, and in those cases the ball that Bob finds will be of the same color as the ball that Alice put in the box. But about half the time, Bob will open the wrong door, and then he won’t find out anything about what Alice put in the box.

But now that Bob has safely recovered and opened the boxes, so it is too late for Eve to do anything about it, Alice can make a public announcement telling which door she used on each of the boxes; it doesn’t matter if Eve finds out at this point. With this information, Bob now knows for which boxes he opened the right door, and he can share that information publicly with Alice. (That is, it becomes public knowledge that Bob opened the right door, but he doesn’t tell anyone what he found in the box.) Now Bob and Alice share a set of random bits; Alice has successfully sent the key to Bob.

What about Eve? She will surely try to intercept some of the boxes while they are being shipped from Alice to Bob. But to find out what is inside, she will need to open the boxes. If she happens to open the right door (the door that Alice used), then she can copy the information, and Bob will never be the wiser. But sometimes she will open the wrong door, and so might change the color of the ball. Now Bob and Alice can conduct a test to see what Eve has been up to. They can publicly compare a small portion of their key, to make sure that Bob really received what Alice sent. If they agree, then they can be highly confident that Eve didn’t open any boxes (or at least that she opened very few boxes). But if they disagree, then they know that Eve has been up to no good.

We can’t stop Eve from trying to eavesdrop; that’s what Eves do. But because quantum information cannot be copied without disturbing the information, we can detect Eve’s activity. If the test is unsuccessful, then Alice won’t use that key to encode a message. But if the test is successful, Alice can converse with Bob secure in the knowledge that Eve cannot listen in.

QUANTUM COMPUTING

We have discussed one feature of quantum information (it cannot be copied) that can be put to use: it can be used for private communication. But there are deeper properties of
quantum information that I think have far greater technological potential. To understand why, let’s return to the differences between classical bits and quantum bits.

Let’s suppose that we have 10 boxes containing classical bits. There are a lot of possible arrangements of those classical bits — lots of ways to put red and green balls in the boxes. But any one arrangement is very simple to describe; I just have to tell you whether each ball is green or red. With quantum bits things are different. Suppose we have 10 quantum boxes. Now it is quite complicated to describe even one typical arrangement of the 10 boxes. In this case, it is not correct to say that each ball is either red or green. Typically, each ball has the potential to be red and the potential to be green, depending on which door we open. Furthermore, the boxes are correlated. Opening any one of the 10 boxes has an “influence” on what happens when we open the other nine, so our description must include a characterization of those influences. It turns out that to give a complete mathematical description of a typical configuration of 10 quantum boxes, I would have to write down about 1,000 numbers.

And the complexity of the description rapidly escalates as I add more boxes. With 20 quantum boxes, we need about 1,000,000 numbers to give a complete description of all the influences of each box on the others. With 30 boxes, we need 1,000,000,000 numbers. It turns out that for a relatively modest number of boxes (about 300), to write down a complete description of a typical configuration would require more numbers than the number of atoms in the visible universe. It is clear that no such description could ever be written down, even in principle.

So there is no hope of even describing the typical state of a few hundred qubits, no way to write down the description using ordinary classical bits. This feature of quantum information seemed very intriguing to Richard Feynman. Feynman was led to ask a very interesting question [5]; he wondered: Might it be possible that a computer that operates on qubits (rather than classical bits) would be capable of performing tasks that would be inconceivable using conventional silicon-based digital technology? Feynman’s idea was that there may be problems that are very hard to solve using ordinary computers that would become easy to solve if we used a quantum computer instead.

To get a better feel for what this idea means, let’s consider an example of a problem that is hard for ordinary computers to solve. You probably know what a prime number is — we say that a whole number is prime if it cannot be divided evenly by any whole number aside from itself and 1. Now, with prime numbers, we can play an interesting game called Find the Factors. I give you a number that can be expressed as a product of two prime numbers, and you have to tell me what those prime factors are. (It’s like Jeopardy: I give you the answer, the product of the two numbers, and you tell me the question: What two numbers did I multiply together to get the product?

Okay, let’s start with this one:

91 = ? × ?

Fig. 6. With a quantum computer, we can make many attempts to solve a hard problem all at once

91 can be written as a product of two prime numbers. What are they? Right, it’s 91 = 7 × 13. But as the numbers get bigger, the game gets a lot harder. Can you do this one?

2537 = ? × ?

With a piece of paper and a pencil and a few minutes, you can probably figure out that 2537 = 43 × 59. As you can see, as the size of the number that we are trying to factor increases, the difficulty of the game escalates very rapidly. Until we get to this one:

| 1807082088674048059516561 | ? × ? |
| 64405905566278102516769401 | |
| 34917012702145005666254024 | |
| 40483873411275908123033717 | |
| 81887966563182013214880557 | |

This 130-digit number can be expressed as a product of two 65-digit prime factors. Finding the factors is hard, but it is not quite impossible — this may be the hardest factoring problem that has ever been solved by a computer. It was done, and it is interesting how it was done — the computation involved a network of hundreds of powerful workstations collaborating and communicating over the internet, and it took several months [6]. But as we add further digits to the number to be factored, the time required to do the computation grows so explosively that, say, factoring a 200-digit number is still far beyond what existing computers can accomplish. So perhaps this is a good context to consider Feynman’s challenge. Classical computers will never be able to factor very large numbers. Could a quantum computer do better?

Why is factoring so hard? Searching for the prime factors of our number is like trying to unlock a padlock; if we can find the
right key (the right prime factors) the key will open the lock. But there are many, many keys to try, many possible prime numbers that might divide our number. We can solve the problem by trying one key after another, until we finally find the key that opens the lock, but because there are so many keys, this takes a very long time. With a quantum computer we can do much better — we can try many, many keys in many, many locks all at the same time. As we have seen, a collection of a modest number of qubits (just a few hundred) can in a sense encode an enormous amount of information. By performing our computation only once, but on qubits rather than ordinary bits, we can achieve the same effect as if we had performed the computation with ordinary bits over and over and over again.

The secret of the quantum computer is that we can invoke a kind of massive parallelism, we can do a very large number of computations all at the same time. Designers of conventional computers often speak of parallelism, of computers with many processors working together on a problem. But a quantum computer can achieve a level of parallelism that we could never dream of with a conventional machine — with only hundreds of qubits, we can perform simultaneously a number of computations that exceeds the number of atoms in the visible universe. We’ll never build a conventional computer with that many processors.

What might this mean in practice? With conventional computers, we can now factor a 130-digit number in a few months, let’s say one month. But if we take into account how the difficulty of the computation grows as we add digits, we can estimate that the same network of computers would be able to factor a 400-digit number in about 10 billion years, about the age of the universe. So factoring a 400-digit number really is Mission: Impossible. Even with vast advances in computing power, we won’t be factoring 400-digit numbers anytime soon. But suppose we had a quantum computer that could also factor a 130-digit number in one month. (That’s a very big assumption, but let’s make it anyway.) Because of the massive parallelism that a quantum computer can employ, the time it takes to do the computation grows at a much more modest rate. We can estimate that it would take a few years to factor the 400-digit number, which would be feasible. Because of this much more favorable scaling of the computation time with the size of the problem, quantum computers will always have a huge advantage over classical computers for sufficiently complex problems. (That a quantum computer could be an efficient factoring engine was pointed out by an exceptionally clever computer scientist named Peter Shor [7].)

QUANTUM HARDWARE

Perhaps you are persuaded that a quantum computer would be a wonderful thing to have if we could only build one. But how will we build one? What sort of hardware will a quantum computer have? If we want to be able to manipulate quantum bits, one way to do that (perhaps not the only way, but one way) would be to encode and process the information at the level of single atoms. The technology now exists to suspend an array of individual atoms in a vacuum using electromagnetic fields, and to store the trapped atoms for a long time. Each atom can be in either one of two possible quantum states, so we can still represent them as red or green balls. Since they are individual atoms, such tiny little fellows, you might think it would be hard to see whether each atom is red or green. But in fact that is not very hard. We can shine a laser on each of the atoms, and if the color of the laser light is chosen just right, then all of the red atoms will scatter the light so they will glow visibly; the green atoms won’t interact with the light at all, so they will remain dark. We easily see, then, which of the atoms are red and which are green.

Of course, we want to do a lot more than just look to see if the atoms are red or green; we want to process the information in the atoms and build up a complex and interesting quantum computation. And in particular, if the quantum computer is to realize its potential to perform tasks beyond what classical computers can do, it must prepare and manipulate configurations of the atoms in which they have complicated nonlocal correlations. I will briefly sketch how this might be done [8]. First we shine a laser on one of the atoms. If we choose the color of the laser light just right, then the light will not interact with the atom at all if the atom is red. But if the atom is green and we leave the laser on for just the right amount of time, then the atom will change from green to red, and at the same time the laser will stimulate that atom, and all the atoms in the trap, to begin vibrating back and forth. If we now direct a laser at another of the atoms, and we choose the proper color for the laser light, then this laser will not interact with the atom.

Fig. 7. Reading out quantum information in an ion trap. When the laser is turned on, the red balls glow, and the green balls remain dark.

Fig. 8. Two types of errors in quantum information. The dragon can change the color of the ball through either door.
Fig. 9A. One qubit of information is encoded in correlations among five different boxes.
Fig. 9B. We can measure the encoded qubit by opening door number 1 on all five boxes, and observing whether the number of green balls is even or odd.
Fig. 9C. Different types of errors modify the correlations among the boxes in distinguishable ways.

We may diagnose the error by opening door number 1 of two boxes and door number 2 of two other boxes — if the number of green balls is odd, then an error has been detected. Four such measurements of four boxes each suffice to identify which box is damaged and what action will repair it if it is not vibrating, but if it is vibrating, and we leave the laser on just long enough, that atom will change color, and the vibration of all the atoms will cease.

Look at what we have achieved. If the first atom is red, no laser ever interacts with any atom and nothing ever happens. But if the first atom is green, then the two atoms change color. This operation therefore induces a correlation between the colors of two atoms in the trap. By performing many such operations in succession, we can build up a complex and interesting quantum computation.

It is currently possible to do experiments like this involving one or two qubits and one or two operations [9]. But for a quantum computer to do computations that compete with the best that digital computers can achieve, we will need to scale this up enormously. We’ll need machines with thousands of qubits (not necessarily atoms in a trap, but qubits of some kind) capable of performing millions or billions of operations. Clearly, the technology has a long way to go before quantum computers can fulfill their destiny to become the world’s fastest machines.

QUANTUM ERROR CORRECTION

How hard will it be to build a large-scale quantum computer that really works? As a theorist, I am interested in any obstacles that may be a matter of principle rather than just a technological barrier. A particular serious concern is that quantum computers will be far more susceptible to making errors than conventional computers. How will we prevent a quantum computer from crashing?

Errors can be a problem even with classical information. We all have bits that we cherish, because information can be very valuable, but everywhere there are dragons lurking who delight in tampering with our bits. With classical information there are well-known ways to protect ourselves against the dragons. Say we have a ball that is supposed to be red. Then we can store three copies of the red ball. Once in a while a dragon may appear and paint one of our balls green. But there is a busy little beaver who checks the balls periodically, and whenever he sees that one of the balls is a different color than the others, he changes the color of that ball so that it matches the color of the other two. We see that redundancy (having three red balls instead of one) can protect us from errors. If the busy beaver is quick enough, he can prevent the dragon from damaging our bits.

But what can we do to protect a quantum bit from the dragon? Here too we can try to use redundancy for protection, but we can’t do it in quite the same way as with classical bits. We can’t replace our box by three identical boxes, the original plus three replicas, because we have already seen that quantum information cannot be copied. Furthermore, when the dragon comes along he might open door number 1 of the box, change the color of the ball, and reclose the box, or he might open door 2, change the color, and close the box. The beaver needs to be able to fix the error without knowing whether the dragon opened door 1 or door 2.

It turns out that it really is possible to protect quantum information from errors [10]. With quantum information, though, it isn’t enough to replace a box by three boxes, we actually need five boxes. And the boxes are not all identical replicas of the information that we want to safeguard. Instead, the information to be protected is encoded in correlations involving all five of the boxes, like the nonlocal correlations between Pasadena and Andromeda. That way, there isn’t any information in any one of the boxes; instead it is shared among all the boxes. That means that if the dragon damages one of the boxes, the information still remains intact, because it wasn’t in that box anyway. Now the beaver can come along and figure out which box the dragon has messed with, and reset that box to its original state. So it seems that redundancy can be used to protect quantum information just as it can protect classical information. However, the redundancy works in a quite different way — information is protected by storing it in correlations involving many boxes.

THE ROAD AHEAD

I have described a lot of properties of quantum information. We saw that the fundamental unit of quantum information is the qubit, which we may envision as a box with a ball inside that is either red or green, such that we can open the box to see what is inside through either one of two doors. The qubits can have peculiar correlations that we cannot reconcile with our usual classical notion of a correlation: the boxes are not like the
soxes. Quantum information cannot be copied, and we may therefore use it for private communication. The mathematical description of even a modest number of qubits is exceedingly complex, and we may therefore use qubits to perform massively parallel computations, achieving an enormous speedup compared to the time required to do a computation on a conventional computer. We can safeguard quantum information from errors by encoding the information in correlations involving many boxes. And I have told you that the first experiments that process quantum information have been carried out in the last few years.

Clearly the technology must progress a long way before quantum computers are ready to fulfill their destiny as the world’s fastest machines [11]. There is a long road ahead. *When will quantum computers that solve hard problems become a reality?* I really have no idea. But we have come a long way in the 50 years since the ENIAC, and it seems reasonable to me that in another 50 years quantum computers will be in widespread use. I could be completely wrong. Maybe quantum computers will never be widely used. Or perhaps I am being way too conservative, like *Popular Mechanics* in 1949.

And what of the shorter-term prospects for putting the weirdness of quantum theory to work for fun and profit? The technology for quantum communication is much more mature than that for quantum computation. Prototype key exchange devices have already been built and tested. These might conceivably see commercial use in just a few years, though at first they would be only for the most paranoid users requiring the utmost in privacy. Ideas generated by recent work on quantum computation are leading experimental physicists to develop new methods for preparing exotic quantum states, and for performing new types of measurements that we could not even conceive of a few years ago. And recent theoretical developments are deepening our understanding of quantum information and the ways it differs from classical information. Particularly significant, I think, is the finding that quantum information can be protected from errors with suitable coding methods; I expect that development to have broad ramifications throughout experimental physics.

The road to quantum computation may be a long one, and there is no telling for sure how long, but it certainly has been and will continue to be a fascinating voyage.

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Preventing Damage by
Hidden Objects in Vegetation

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ABSTRACT

The paper presents the experimental radar-based sensor to operate in environment with vegetation cover for detection and discrimination there the small-sized invisible dielectric and metallic objects. This sensor constitutes a vehicle-housed emergency system for surveillance of area with vegetation ahead on the path of moving vehicle to prevent its contact with hidden objects. The emergency system functioning in basically implemented by real-time electromagnetic imaging of the scene of interest and its following image processing to enhance the target responses. The developed and tested experimental radar techniques are under consideration. The results of experimental examinations in field are presented and discussed.

INTRODUCTION

In this paper a potential of the UWB time-domain radar-based remote sensing system to detect and discriminate small-sized dielectric and metallic objects hidden in vegetation-covered media is treated for the vehicle emergency system design. Such system should provide surveillance of vegetation-covered area, i.e., a scene of interest, ahead on the path of a moving vehicle to prevent its possible damage caused by contact with the hidden harmful invisible objects in vegetation.

The detectable targets should be characterized by their spatial position, shape, dimensions, physical nature to make a decision concerning its threat degree for vehicle. Reaching this goal the radar imaging of scene of interest is implemented in this study for automatic detection and recognition by special designed set of the DSP-based signal processing techniques.

Practical necessity of presented studies is originated from the natural phenomenon common for many agricultural regions of East Europe. This phenomenon results from geological history of the moraine period and characterized by so-called “growth” of stones from the earth. For example, such moraine stones can be dispersed in the crop field on the path of harvest machinery, caught by its harvester and cause its damage. The buried ammunitions and unexploded ordnance objects of World War Two also demonstrate similar behavior.

Among other remote sensing techniques like optics, infrared, radiometric, millimeter-wave radar, and others only ultra-wide band (UWB) radar with the effective 0.5 - 1.5 GHz frequency band has the potential to look through vegetation, grass, foliage etc. This chosen frequency band is optimal due to a common trade-off between minimum attended loss in vegetation propagation and maximum spatial resolution should be achieved in radar [1].

The designed emergency sensor is based on the UWB time-domain radar due to this author’s early experience in design and applications of time-domain ground penetrating radar (GPR). Generally GPR systems are widely employed to obtain electromagnetic section of opaque media like soils, rocks, snow cover, ice, etc. [2]. A modification of GPR-like system has been before examined for vegetation-covered environmental operation and this work is further development of the previous study [3].

The operation media for the designed system is a crop field. It is more statistically uniform than the high-cluttered environments for the land mine detection. The last problem is similar to that studied herein [4]. So the automatic detection and recognition can be achieved for “stone-in-crop field” in more easy way than for land-mine detection. The more complex environmental scenarios can be also involved in study by introducing the adequate signal processing techniques similar to those developed in this study [5].

BASIC RESEARCH APPROACHES

As a matter of fact the potential of radar-based sensing system is a function of the radar system performances and the features of the scene of interest including environmental
conditions and target types. The radar performances are followed from properties of its antennas, transmitter, receiver, and all signal processing techniques implemented by electronics and software. The operation environment is described by vegetation type like grass, crop, etc., with the definite biometrics features such as architeconics, height, density, humidity, and so on. All these environmental factors have real stochastic behavior demanding special care to estimate their influence on the registered electromagnetic scattering events and, finally, the achieved radar performances.

For the above problem, a stone hidden under vegetation cover is a target to be detected. The RCS for energy-based detection and the signature for discrimination can characterize target in ordinary mode [6]. Both target features depends strongly on the contrast of electrical properties between target and background, which is formed by vegetation tip and terrain surface. The receiver-operation characteristic (ROC) can be employed for estimation of the overall radar system potential in the context of probabilistic problem nature [6]. The radar ROC should present detection and false alarm rates versus signal-to-noise ratio (SNR) and signal-to-background ratio (SBR).

Let us consider the principal technical aspect of the radar-based emergency system implementation.

There are two main modes: stand-over and stand-off, to employ the UWB high-resolution radar for target detection and discrimination in vegetation and subsurface like schematically shown in Figure 1. The stand-over mode is applied widely in GPR practice especially for a hand-held radar [2]. The stand-off mode is more preferable for the designed system due to opportunity to monitor large area at safe distance before moving vehicle with installed radar [7]. Also in this case stochastic medium does not disturb the radar antennas in contrast to the stand-over mode [5]. So in this case the radar has more stable operation behavior. Again from geometrical point of view there is some uncertainty of target position in Figure 2A – in contrast to Figure 2B – due to geometrical shape of equal double-travelling time traces of the antenna footprint.

The stand-off radar concept has static and dynamic implementations for its examination. For simplicity reasons the static experimental assembly, in Figure 2A, is first used. For this case testing assembly consists of the stationary mounted radar on the tripod and a set of movable test targets shown later in Figures 5A and 5B. The dynamic experimental set-up, in Figure 2B is a prototype of developing radar emergency system, must operate being housed on movable platform or vehicle.

In order to reach high-resolution features in radar a short-pulse signal or equivalent wide band is above chosen on the competitive base. In the time-domain radar the pulse antennas with shock excitation enable such features. Antenna
Fig. 3. The UWB experimental radar structure

illumination forms a scene of interest covered by antenna footprint. The size of antenna footprint depends on height of antenna installation and its down-look angle. Note that energy pattern of pulse antenna with transient excitation is too wide resulted in large footprint [8]. The last has positive and negative aftereffects in radar. The negative aspect is strong background scattering and positive one is absence of special scanning to monitor the definite-sized area.

SIGNAL PROCESSING

The simple case of emergency system will be under examination, which is based on single-receiver monostatic radar. Nevertheless the simplicity of the monostatic single-receiver UWB time-domain radar enables investigation of all principal features on the subject discussed. The receiving antenna array will be next research step and is in progress.

Due to the use of one-channel receiver in radar a 1-D dynamic presentation of scene of interest is shown conditionally in Figure 3 is employed here. The radar imaging of scene of interest is represented in Figure 2 in a form similar to common B-scan or radargram for GPR data [2]. But in this case the vertical axis of radargram presents the distance between the target and the radar that changes in time due to their mutual replacement. The horizontal axis is current or scan time.

For example, one can observe in Figure 3 two typical predictable cases of target-radar approach. If the target is directly spaced on the axis of mutual approach the trajectory as straight line is registered. If the target is shifted from this axis the curved trajectory line is obtained. Of course, there is some uncertainty in the last case: From which side, left or right, in accordance with the approach axis, is target located? However this can be resolved by using at least one additional receiver channel to implement a receiving array in radar.

The next important moment should be stressed is one that in order to overcome antenna pure directivity and its following consequences discussed above two principal radar techniques will be employed:

1) the synthetic aperture technique to improve spatial resolution due to effect of mutual replacement radar and scene of interest with target when antennas with inherent low directivity are employed [1]; and

2) the moving-target-indication technique common for radar operating in air to overcome masking effect of strong background scattering [6].

The features of both the synthetic-aperture technique and the moving-target indication are examined experimentally in this study. The final goal is the development of the relevant signal-processing algorithm should be tractable for
not the actual for the treated uniform agricultural fields operation as mentioned. Besides radar’s antennas and electronics features the signal processing gains sufficiently the growth of radar potential.

EXPERIMENTAL TECHNIQUE

The UWB time-domain radar system under examination in Figure 3 is based on the adopted components of UWB radar used before as a GPR system. This radar system is characterized by utilization of the active pulse bow-tie antennas with backside reflector. Those antennas are directly terminated to the front-ends of the transmitter and receiver. The transmitter has 50 Volt pick pulse to drive the antenna with 100 kHz pulse repetition. The receiver has about 50-microwatt MRS with stroboscopic sampling and the following 10-digit ADC. The radar return is processing by some radar electronics units like temporal AGC of 60 dB range and mainly by DSP computer card for real-time processing presented below. All radar data are stored on the hard disk of a portable computer with real-time visualization of the scene of interest.

Two kinds of targets have been involved in the system field-testing program. The first target is a stone shown in Figure 5A of about 10cm³ volume. For static examinations this stone is drug by a cord as seen in Figure 5A. The next target applied for calibration is a vertical dipole made from telescopic flagpole antenna mounted on foam plastic base in Figure 5B. This antenna is comfortable due to possibility to change its height in process of testing for radar performance estimation.

Static examination set-up is shown in Figure 5C. There is a radar monostatic head with transmitter and receiver and their antennas in single case installed on the tripod. The active antennas terminated directly to transmitter and receiver units, which are connected via coaxial cable link with other radar electronics and computer. A target attached to towing lag is also seen in Figure 5C.

The dynamic examination set-up has been implemented on the base of car in Figure 5D. The height of antenna installation on the special chassis was about 3 meters that corresponds to the possible installation height on harvest machinery.

Preliminary experiments have been conducted with both the dynamic and the static testing assemblies. In such, the radar-based emergency system and its potential to solve the above formulated problems have been successfully examined.

EXAMINATION RESULTS

The only “stone-in-meadow vegetation” scenario is considered below. The examination results are presented in the form of electromagnetic images at scene of interest. Those images are formed by conversion of bipolar radar responses into electromagnetic image like the B-scan for GPR systems.

Next, we show and discuss typical experimental results obtained by implementation of above presented testing techniques. First, the simplest experimental arrangement with the stationary radar and the movable target, the stone in Figure 5A, on the terrain surface without sufficient vegetation is
Fig. 6. Results of static examination when target is located on area without sufficient vegetation
demonstrated in Figures 2A and 5C. The radar-registered data are presented in Figure 6 as a screen copy of the computer window where the radar returns are displayed in real-time mode due to the DSP technique used.

The left picture in this window shows the initial radar data presented in the format discussed before. In this case the distance coordinate is along the vertical axes and the current time coordinate along the horizontal axes. The distance along the vertical axis is ranged up to 10 m and total examination time is about 6 s. Those figures correspond to the target velocity of about 1.5 m/s that is a typical speed for harvest machinery movement in field operation.

As seen in Figure 6, the original image of the scene of interest is under powerful masking interference’s signals due to strong background scattering. A trajectory of mutual approach of the target and the radar is slightly visible as a fuzzy line drawn from the below-left corner to the upper-right corner. This line is observable only slightly for the original data and then it is better visible after processing. The aforementioned velocity value of mutual approach of the target and the radar is the inclination of the trajectory fuzzy line. A residual uncompensated noise is present here too due to fluctuations of background scattering in the process of radar/target movement. Special signal processing techniques to enhance SNR figure should be employed and is discussed later.

When the target is hidden in vegetation for static examination, the situation is worse than previous case as seen in Figure 7.

Due to target movement trough vegetation the last is swung makes more non-stationary background scattering. In turn, this unfavorable event increases uncompensated noise on the left part of the presented picture.

Figure 8 illustrates the results of the dynamic examination to locate stone hidden in 20-30 cm meadow vegetation of sufficiently non-uniform density. The velocity of car movement is about 2 m/s (7 km/h) and slightly non-uniform. Such movement is expressed in Figure 8 as non-constant inclination of the trajectory. There are also some false targets, or clutters, formed by hillocks and separated fragments of vegetation of high density and height. It is possible to separate these scattering events by the resonance-based discrimination [4] due to different features of the registered waveforms for stone and clutter electromagnetic scattering. The vertical-to-vertical polarization is considered but the full-polarimetric technique [4] is also very preferable in this case.

Further investigations have been conducted to implement the advanced signal processing approaches that enable improving the system performances like ROC. For illustration, Figure 9 shows four consecutive images of the scene of interest for the case of static examination with stone on the terrain surface without sufficient vegetation. The conditions of this experiment are the same as shown in Figure 6. The corresponding radar echo-waveforms for various processing stages, which demonstrate transformation and discrimination of useful signal components masked initially by a background scattering, are also shown in Figure 9.
Fig. 9. Signal processing flow-chart and typical scene images and waveforms

The first upper image is non-processing with SBR magnitude equal to about –15 dB. The next image after the moving-target filtration include a residual uncompensated noise. This noise with SNR figure ≤–6 . . . – 8 dB is produced due to unavoidable fluctuations of background scattering resulting from target-radar replacement. The third image in Figure 9 results from its upper neighbor after eliminating the residual noise by the corresponding filtration. On this stage SNR ≥ 10 dB that is enough for reliable threshold detector operation in the accordance to the standard ROC [6]. The results of one-sided threshold applied to previous stage processed data is shown in the last lower image in Figure 9.

DISCUSSIONS AND CONCLUSIONS

A brief summary of the test results and the future directions of radar-based emergency system development are:

1. The presented idea of the radar-based emergency system is functional for its implementation due to UWB radar high-resolution features with the corresponding signal processing techniques.

2. Additional efforts should be directed to optimize system components like antennas, radar electronics, and its general behavior (system algorithms of operation).

3. In general, the sufficient improvement of the system performances (high probability of detection, low and stable false alarm rate, etc.) can be achieved by the development of the optimized detection strategies and improved target recognition.

4. The theoretical target signatures can be employed to build the advanced matched-like detector schemas [4].

5. Sufficient improvement of radar receiver operation characteristics can be achieved by application special 2-D signal processing and detecting techniques.

6. 2-D presentation of scene of interest requires application of two and more channels receiving array with additional opportunities for target recognition.

7. Full-polarimetric technique is also preferable due to advanced opportunities to discriminate and recognize target by processing its response with estimation of the target 3-D geometrical features.

8. It was estimated that registered by radar background scattering depends on biometrics features of vegetation and can be useful for setting of operation modes of harvest machinery.
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Security Systems Research and Testing Laboratory
at Edith Cowan University

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ABSTRACT

The testing and evaluation of sophisticated security systems has remained in the domain of governments in national facilities and the commercial security industry through manufacturers and engineering consultants. As well, the production of testing protocols and industry standards has been developed by national organisations, professional security, and engineering bodies in the appropriate security fields.

The Security Systems Research and Testing Laboratory in the School of Engineering and Mathematics at Edith Cowan University (ECU), Perth, Western Australia has commenced operations in research, testing, and evaluation of security systems. This paper will describe the first year of operation of the Security Systems Research and Testing Laboratory, and will describe the role that testing and evaluation of security systems plays in the education and training of Security Science graduates, as well as the benefits that the Laboratory brings to the security industry through its testing programme.

INTRODUCTION

The Security Systems Research and Testing Laboratory (SSRTL) in the School of Engineering and Mathematics at Edith Cowan University (ECU) commenced operations in late 2004 with projects in research, testing, and evaluation of security systems. The SSRTL was established to develop reliable and valid testing protocols for security systems, and to provide an independent testing laboratory for third party assessments of security devices. The objectives of the Security Systems Research and Testing Laboratory have been developed to fulfill the academic and industrial requirements for the advancement of Security Science as an academic discipline [3]. These specific objectives are:

- Provide a rigorous test and development facility,
- Assess, analyse, and report on security technology,
- Initiate development in establishing protocols and standards for security technology,
- Provide research and education in security technology,
- Further the academic discipline of security science, and
- Provide a commercially-available research and test facility.

Performance testing of security equipment and the development of testing protocols for reliable and valid assessment of equipment are two of the primary functions of the Security Systems Research and Testing Laboratory. The advancement of these functions has commenced at SSRTL where macro and micro systems are being evaluated, and the foundation for equipment testing is being established through a risk management standard. This paper will discuss these two functions of the SSRTL and describe these activities of the Laboratory in the context of the objectives of the testing facility.

SYSTEMS TESTING

The testing of security systems and devices has commenced at the SSRTL with both academic research staff and students participating in the development of testing protocols and evaluating the performance of the security technologies. A brief description of the technologies will be provided and some comments on the testing process will be presented.

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Intelligent CCTV

A real-time video analysis system that raises an alarm when objects within the camera’s field of view violate threat-specific pre-programmed rules was tested. The processes of detection, identification, classification, and tracking enable the system to decide the level of threat posed by an object, according to structured rules of detection. As a result, appropriate algorithms enable the system to monitor the flow patterns of objects such as moving crowds of people, and initiate an alarm when an object goes against the flow pattern. Some features of the system include:

- unusual changes in flow patterns of objects such as a moving crowd avoiding, moving away from, or moving toward a particular area, and
- The insertion of tripwires into the field of view of the camera enables the intelligent CCTV imaging system to protect sensitive zones or areas.

The intelligent CCTV system was tested according to the performance claims of the manufacturer for its capability to detect, identify, classify, and track objects in real-time. Both routine and novel testing situations were devised to evaluate the performance of the system, and test protocols were designed to test limiting conditions for the performance of video surveillance technology.

Biometric Devices

Students have been introduced to testing procedures through the introduction of courses on Security Technologies
Testing Methodologies where testing standards and methods are discussed and developed. Students are required to develop a testing plan for a simple fingerprint biometric recognition system. They are encouraged to apply rigor to the testing schedule with due diligence to the concepts of reliability and validity. This study programme has considerably enhanced their appreciation of the application of security technology in the security management plan.

TESTING PROTOCOLS

The development of testing protocols is an important facet of the activities of the SSRTL as the testing schedules are critical in the quality control through reliability and validity. The Australian Standard / New Zealand Standard AS/NZS 4360:2004 Risk Management, is a generic standard which is applied to the practice of risk management across public and private sectors, across industries and across organisations. Recognised as best practice in risk management, and as such serves as the foundation for the development of testing protocols in the Security Systems Research and Testing Laboratory.

The Risk Management Process

AS/NZS 4360:2004 is based on the Risk Management Process, consisting of seven distinct elements, with the relationship between each of these elements shown in Figure 1. The assessment of risk depends upon the context of the situation, and the treatment of risks is an outcome of the risk assessment. Both communication and consultation, and monitoring and review are constants in the risk management process cycle.

- **Context:** sets the scope and parameters of the risk management process.
- **Risk Identification:** fundamental element that requires risks to carefully identified.
- **Analyse the Risk:** likelihood of the risk occurring, and the consequences if the risk is realised.
- **Evaluate Risks:** enables decisions to be made for the management and control of the risk.
- **Treat Risks:** Security strategies are established with testing of security equipment.
- **Monitor and Review:** operates through the lifecycle of the risk management process.
- **Communicate and Consult:** two-way dialogue is maintained with decision makers and relevant stakeholders throughout the risk management process.

Model for Security Equipment Testing and Evaluation

A model has been developed for security equipment testing and evaluation (Figure 2) that is comprised of five stages of intelligence acquisition and analysis, development of plan, client liaison, execution of the plan, and the reporting function. These processes in the model are undertaken at two different testing levels.

**Level 1:** laboratory environment, which determines if the security equipment is technically and physically capable of delivering the clients needs; and

**Level 2:** operational or simulated operational environment, which assesses the suitability of the equipment to perform within its intended environment in its intended role [2].

**Level 1 Testing**

Level 1 testing is conducted within a controlled laboratory environment, where operational activities, equipment operation, platform of operation, length of operational time, subject diversity, and other factors are largely controlled. The laboratory environments is ideal in preliminary testing and evaluation stages, as controlled conditions allow specific elements of security equipment to be isolated and repeatedly tested. The reliability and validity of security equipment is the primary objective in the model (Figure 2).

Reliability of the equipment is its ability to repeatedly produce the same results under the same circumstances, and the validity is concerned with the reproduction of the performance claims from the manufacturer. These concepts must be considered in the testing regime, as they determine the credibility of the outcomes of the testing procedures. Hence, reliability is the degree of confidence in which a testing regime can repeatedly yield the same results, while validity is the degree of confidence in which testing outcomes assess what they purport to assess [1], according to performance claims for the security technology. Reliability and validity are crucial to the credibility and effectiveness of test results. This view has been supported by [4] who addressed the issues of testing methodologies which have been developed by equipment usability testers with no account of the reliability and validity of data produced by the testing methodologies.

**Level 2 Testing**

Level 2 testing and evaluation is conducted in an operational or simulated operational environment, which evaluates the suitability of the security equipment to operate in its intended environment. The stages of Level 2 testing are:

**Stage 1 Intelligence Acquisition and Analysis:**

This element is primarily concerned with the acquisition and analysis of intelligence as it outlines the aims and objectives of testing methodologies to be developed. The
acquisition of intelligence generally precedes risk assessment or risk management-related reports.

Stage 2 Development of Plan:
The development of the plan will include the aims and objectives of testing and evaluation of the security equipment with recognition of all elements and characteristics of the security equipment for testing and evaluation.

Stage 3 Client Liaison:
The proposed testing and evaluation plan is presented to the client for approval as the client will make decisions from these results. If the plan is not appropriate, then the tester must go back to the intelligence acquisition and analysis stage and recommence the testing cycle.

Stage 4 Execution of Plan:
The plan is executed according to the aim and objectives.

Stage 5 Reporting:
A full testing and evaluation report is formulated for the client, providing results and an interpretation of the results. This will provide the client with both a qualitative and quantitative assessment of results. The reporting phase is conducted at both Level 1 and Level 2 testing.

MODIFIED RISK MODEL

Applying the testing model (Figure 2) for security equipment testing and evaluation to the AS/NZS 4360:2004 risk management model extends the capacity of the model for security risk management as shown in Figure 3. In this modified security risk management model, the new element of “security equipment testing and evaluation” is executed according to the testing model (Figure 2) for security equipment.

This model of security equipment testing and evaluation is encapsulated within this new element and integrated into the risk management process. As like other central elements, it also requires a relationship with the communication and consultation and monitor and review elements in order to effectively address security risks.

REFERENCES


Strategy of GPR Searching for Low Radar Contrast Plastic Pipes in Ground

L.A. Varyanitza-Roshchupkina & G.P. Pochanin
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ABSTRACT

The results of computer simulation of pulse signal scattering by a plastic pipe buried in the ground as well as simulation results of Ground Penetrating Radar (GPR) image of ground-filled trenches have been represented in the work. The “skeleton diagram” of a trench image has been developed. The strategy of GPR searching for low radar contrast plastic pipes in ground (in back-filled trenches) has been considered on the basis of indirect criterion which is the existence of a trench containing buried pipes.

INTRODUCTION

It would be reasonable to use Ground Penetrating Radar (GPR) for search problem solution on account of their environmental safety, relatively low-cost, and efficacy. However, there are such search problems among others that are seemingly impossible to solve by up-to-date georadar because of very low radar contrast of search objects in the radar image. As a matter of fact, what kind of georadar it should to detect a crack or hole in a water pipe buried in the ground or plastic pipe in ground with permittivity being close to plastic permittivity, etc.

However, in a number of cases it is possible to use approaches permitting a search for such objects using current equipment. One of these approaches providing a successful solution to the problem of searching for plastic pipes in ground is considered in this paper.

PROBLEM DEFINITION

Let a search team have the GPR with a pulse duration of approximately 2.5 ns. It is necessary to find a plastic pipe of about 5 cm in diameter in clay soil at a depth of 1 m. The GPR image illustrated in Figure 1 has been obtained after ground sounding. The problem is to answer the following questions:

- Are there plastic pipes in this route? and
- If so, then how many and what are their coordinates?

It is natural to suppose that a hyperbolic response should be in a radar image of the ground profile received after pipe crossing. However, in the given profile there is no apparent hyperbolic response by reason of a very low contrast radar image of the pipe itself – on the one hand; and the presence of more contrasting subsurface heterogeneities in ground (including inequalities of the ground surface) – on the other hand.

SIMULATION OF PULSE SIGNAL SCATTERING BY GROUND CONTAINING A PLASTIC PIPE

First, it is necessary to evaluate the amplitude and shape of a signal scattered by the desired pipe. As radar detection is realized by a short pulse of the electromagnetic field, and an object is at a short distance from the antenna system, then the best way to make this evaluation is to solve the electrodynamic problem of electromagnetic field pulse diffraction by a plastic pipe buried in ground using the finite-difference time domain method (FDTD). This method is remarkable for its universality, permitting us to simulate different real-world electrodynamic problems without restriction on profile complexity and signal format.

The program “GRIDER” [1] designed by authors and enabling both 2-D and 3-D simulation has been used for simulation of the considered problem. Let’s use the 2-D approach to estimate the amplitude of a pulse of the electromagnetic field strength incoming to the receiving antenna from a plastic pipe 5 cm in diameter buried in ground at a depth of 60 cm. Suppose that the antenna system composed of the source Tr and the observation point R that are spaced at a distance of 50 cm and lifted to a height of 5 cm above ground.
level (Figure 2A). The center of the antenna system is directly above the buried pipe.

The electrical ratings are as follows:

- ground
  - relative permittivity = 9
  - conductivity = 0.005 siemens per meter

- air
  - relative permittivity = 1
  - conductivity = 0 siemens per meter

- plastic pipe
  - relative permittivity = 5
  - conductivity = $10^{-3}$ siemens per meter.

A field pulse is excited at the transmitting antenna point (source). Its polarization vector of the electric field strength is directed along the pipe axis, and its time-amplitude characteristics are depicted in Figure 2B.

Two waves (Figure 2C) arrive at the observation point $R$ being at the receiving antenna point. The first wave is transmitted from the source directly to the observation point (it occupies the time interval from 2 ns to 7.5 ns). The second wave is generated as a result of radiated pulse propagation from the transmitting antenna to the pipe, field pulse scattering by the pipe and scattered pulse propagation from the pipe to the point of observation (it seizes from 14 ns to 19 ns). In the given case, the amplitude of a signal carrying information concerning the presence of the subsurface plastic pipe is ~240 times smaller than the amplitude of a signal passing from the source directly to the observation point.
Fig. 3. Pipe in a trench:
Fig. 3A. Simulated Problem; Fig. 3B. Electric field strength in the observation point:
1 is the pulse advancing from the source directly to the observation point;
Fig 3C. Scaled-Up Signal section B) (round fill markers correspond to signal 2,
square markers correspond to signal 3)

Fig. 4A. Back-filled Trench Image;
Fig. 4B. “Skeleton Diagram” of the trench image

Thus, the amplitude of the field scattered by the plastic pipe is negligibly small in comparison with the amplitude of the field excited by the source at the observation point. This implies the plastic pipe detection probability by this locator is extremely small. The cause is a very low radar contrast of the pipe. But how to find a low radar contrast pipe?

SIMULATION OF GPR IMAGE OF A PLASTIC PIPE BURRIED IN A TRENCH

Usually, plastic pipes are lowered into trenches and then covered over with earth. As a result such ground characteristics as density, porosity, and, consequently, temper and hence – permittivity and conductance in a back-filled trench differ greatly from the same characteristics of the virgin ground out-of-trench. This fact as well as a relatively deeper and wider trench (in comparison with a pipe diameter) can cause a situation when the trench will be more contrasting and so clearly visible in the GPR image.

The next simulation is shown in Figure 3. The trench width is 40 cm; its depth is 60 cm. The ground electrical ratings within the trench are as follows: relative permittivity = 6; conductivity = 0.005 siemens per meter. As above, we will estimate relative amplitudes of signals generated at the observation point (R) on exciting the source (Tr) by a field pulse with time-amplitude parameters depicted in Figure 2B.

But simulation data shown in Figures 3B and 3C are insufficient for realization of this strategy. A signal, similar to represented ones, can be generated as a result of scattering by other objects. How to distinguish a trench from other objects in a GPR image?

SIMULATION OF GPR TRENCH IMAGE

The GPR antenna system moves by a definite route during mapping. It means that during surveying the GPR displays attitude information of subsurface objects being within a probing route. Since the back-filled trench is a relatively large object, the trench sizes have a certain influence upon the trench image. This can distinguish the trench from other objects.

For imaging the back-filled trench in the profile we will carry out simulation like in paragraph 3 for a series of positions of the sounding signal source and point of observation. The source and observation point for every following problem moves simultaneously 5 cm along the ground surface from the left boundary of the considered area to its right boundary. At
that the trench remains in the centre of the analyzed area. This is equivalent to georadar sounding when the antenna system moves above a trench. Then from a set of simulated signals we will image the back-filled trench using the program of georadar data processing “GPR ProView” [2] by the variable density method [3, 4]. In the given case the data processing lies only in subtracting a selected signal (the first) from the whole profile. This procedure refines the image contrast due to the subtraction of a powerful but spurious signal from radar data, which passes from the source directly to the observation point.

The received image of the back-filled trench is shown in Figure 4. Light and dark horizontal segments in the upper part of the figure correspond to the upper outcropping part of the trench. The presence of these segments is conditioned by the difference of ground electrical ratings in the trench and in the rest considered area. As is obvious the vertical boundary of the trench is not reflected in its image. Also by reason of the difference of ground electrical ratings, the trench bottom causes the presence of a scattered signal in the shape of a hyperbolic curve being directly under the above segments.

The results of simulation by the program “GRIDER” of back-filled trench images having different sizes at different ground characteristics are also set out in the work [5]. The most typical images of back-filled trenches have been selected and represented in that work. These images differ naturally from one another, but all have something in common – the presence of a horizontal segment at the level corresponding to the ground level as well as the hyperbolic curve under this segment. This community permits to draw a “skeleton diagram” (Figure 4B) denoting the presence of the back-filled trench in the profile. Depending on objective parameters of the antenna system the radiated and received signal waveform can differ from that shown in Figure 2B in the presence of afterpulse oscillations. This will make the number of horizontal segments and hyperbolic curves in the profile increase. But these two elements (“skeleton”) are steadily in images of any back-filled trench.

**CONCLUSION**

Thus, the results of simulation of pulse signal scattering by a plastic pipe buried in ground as well as a pipe located in a trench permits us to estimate the image contrast of the pipe and trench for ground sounding by pulses with specified time-amplitude characteristics. It has been shown that when the pipe contrast is very low, the bottom of a trench containing the pipe is quite clearly visible.

Simulation and analysis of images of trenches differing in sizes and electrical ratings permit us to mark features being typical for trench images and to draw a generalizing “skeleton diagram” of the trench.

The received results allow us to propose the valid strategy of searching for low contrast plastic pipes in ground by indirect features – i.e., the presence of a trench containing a target pipe. Like any other search strategy based on using indirect features the proposed strategy doesn’t guarantee the undoubted object detection. However, the use of the described approach permits us to relax essentially requirements to searching equipment, and in a number of cases, to go on from a problem being unsolved in the present conditions to a more difficult but solvable problem.

Now, when considering one can affirm with confidence that in the given georadar profile the desired plastic pipe buried in a trench is at the range mark 10.5 m. A corresponding enlarged profile fragment is depicted in Figure 5. The results of digging have confirmed it too.

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FROM THE PRESIDENT

2006 in Review

I wish to thank all AESS members for continuing their membership for 2007! Our membership has been in slow decline over the past ten years or so. There are many reasons, but, the AESS Board of Governors (BoG) and I have tried to stem the tide this year. Our VP-Member Affairs, Jim Howard, has initiated a program to provide monetary awards for all AESS chapters increasing their membership. Ron Ogan has nurtured our Chapters and is planning a Chapters Summit in conjunction with Sections Congress in Quebec City (Canada) in 2008. Many programs outside North America were inaugurated last year by Past-President Paul Gartz. Zafar Taqvi, Director of Transnational Operations, has inaugurated a Transnational Incentive program for Chapters in Regions 7-10.

Ed Reedy has greatly improved our publications. Ed will step down this year and be ably replaced as VP-Publications in January by Joel F. Walker. Peter Willett, AESS Transactions Editor-in-Chief (EIC), has maintained our best technical publication. Evelyn Hirt, as EIC, has made Systems Magazine “world class.” The majority of our membership works in industry and wants articles of practical application. This has been accomplished through our special Tutorials in Systems. In addition to the Tutorials, Systems ventured into new opportunities by publishing Challenges of Education in Engineering (March 2006), Space Education: A Collection of Seven Papers (July 2006), and Radar: A Case History of an Invention (August, 2006).

We are a financially healthy organizational unit of IEEE with reserves of several million dollars. This has been accomplished through our financial sponsorship of conferences, among other things. Thanks to Barry Breen, VP-Conferences, and Charles Gager, Treasurer, has maintained strong financial controls. Charles Gager will step down at the end of this year and be ably replaced by George Dean, past-treasurer, IEEE Regional Activities Board (RAB).

Speaking of AESS-sponsored Conferences, Bob Rassa, our Executive VP, did an outstanding job with AUTOTESTCON 2006, held at the Disneyland Hotel. Our prestigious Pioneer Award for 2006 was presented to William Fishbein for his work on the Firefinder series of radars at this event. (See the September 2006 issue of Systems Magazine.) Erv Gangl, Awards Chair, did the research and identified William Fishbein for this award.

We held our BoG meeting in conjunction with AUTOTESTCON. Not only did Mickey and Minnie Mouse entertain us during the meeting series, but, at the banquet, Elvis and Marilyn were available for photo-ops. Bob Rassa arranged over $13,000 worth of prizes to be awarded at the conference banquet. My wife, Barbara won a set of his and hers Mickey Mouse watches.

Saj Durrani has established a Distinguished Tutorials program this year. Saj will step down and be replaced as VP-Education in January by Bob O’Donnell. Bob’s goal next year is to establish a set of radar tutorials based on those developed at Lincoln Labs (MIT) to be incorporated into the IEEE Expert Now program.

Jim Huddle, VP-Technical Operations, has maintained our technical panels and our Distinguished Lecturers bureau. Speaking of which, I have invited Myron Kayton, AESS Distinguished Lecturer, to speak at the University of Missouri at Rolla (UMR) in November to their IEEE Student Branch. We are in the process of reviving our IEEE AESS Student Branch Chapter at UMR.

Myron Kayton will repeat his speech, Back-Side Lunar Observatory at the Boeing St. Louis Prologue Room to a group of the Boeing Technical Fellowship and aspiring managers, many of whom are IEEE members. Our new Graduates-of-the-Last-Decade (GOLD) Chair, Joe Pighetti is planning a GOLD track at next year’s IEEE Systems Council Conference in early April, in Hawaii.

2006 has been a very rewarding experience for me and I hope it has been for you, our members, also. If there are any programs you would like us to investigate, please email me at: j.leonard@ieee.org.

Jim Leonard
President, AESS 2006
December 2006

Distinguished Lecturers Program

James R. Huddle, Chair

All AES Chapters and IEEE Sections are encouraged to take advantage of the AESS Distinguished Lecturers Program for their regular or special meetings. We have selected an outstanding list of speakers who are experts in their fields. The AES Society will cover up to $500 of the speaker's expenses for travel in North America, with any remaining amount normally covered by the AES Chapter or Section or by the speaker's organization. For travel outside North America, the AES Society will cover half of the speaker's expenses per trip, up to a maximum of $1500. The procedure for obtaining a speaker is as follows: If a Chapter or Section has an interest in inviting one of the speakers, they should first contact the speaker directly in order to obtain his agreement to give the lecture on a particular date. After this is accomplished, and if the Chapter or Section wishes to request financial support from the AES, it should contact James R. Huddle on (818) 715-3264, F (818) 715-3976, j.huddle@ieee.org at least 30 days before the planned meeting, in order to obtain approval for the financial support. The list of distinguished speakers who have expressed their willingness to speak to Chapters or Sections, along with their organization, topics, and telephone numbers, is given below.

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<th>Title</th>
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<td><strong>Target Tracking and Data Fusion: How to Get the Most Out of Your Sensors</strong></td>
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28 IEEE A&E SYSTEMS MAGAZINE, DECEMBER 2006
FROM THE EDITOR-IN-CHIEF

What a Year!

The editorial staff of Systems humbly accepts President Leonard’s kudos that we have made Systems Magazine “world-class.” I could not have taken Systems to this point without help. So, let me take this opportunity to publicly thank all of the Editors of Systems Magazine (see inside front cover) for their support and dedication to the quality of the magazine this year. There have been a few bumps along the way with clearing manuscript publication backlogs, but plans are in place to avoid these problems in the future. We hope you enjoyed what Systems offered in 2006. Our intent is to be the premiere IEEE magazine for providing quality articles, in AESS-designated fields, that are enjoyable and highlight the interests of the practitioner. We have and will continue to explore special offerings such as Tutorials and Radar: A Case History of an Invention (August 2006). Remember, Systems is always interested in hearing from you, our readers.

– Evelyn Hirt

CANDIDATES FOR ELECTION TO AESS BOARD OF GOVERNORS

Eight AESS members will be elected to three-year terms (2008-2010) as members of the AESS BoG at their April 2007 meeting. The Nominating Committee is responsible for developing a slate of nominees with the broadest representation of geographic diversity and technical interests of AESS membership. We need your help! We encourage members to suggest candidates with strong professional credentials and dedicated interest in our society’s success. All suggestions are considered.

The requirements for nomination, besides membership in AESS, are the capability and resources to attend at least two BoG meetings per year and to devote several hours per month to AESS affairs.

Please send suggestions by February 28, 2007, to Paul Gartz, Nominating Committee Chair, or any officer or BoG member. Addresses, e-mail, and phone numbers are on the inside back cover of this magazine.

FRED NATHANSON MEMORIAL RADAR AWARD

Nominations Wanted

Established to grant recognition for outstanding contributions to the radar art, this award, consisting of a plaque and honorarium, is to recognize a member of AESS who has not exceeded the age of 40 in the year nominated.

Nominees must be a member (in any grade) of IEEE/AESS and must have made outstanding contributions to the radar art; nominations must permit appraisal of the contributions. A nomination (the form can be obtained from: http://www.ewh.ieee.org/soc/aes/nathansonAward/) accompanied by 3 to 5 letters of reference (on web) must reach Michael C. Wicks, Chair, Awards Committee, IEEE/AESS Radar Panel, c/o AFRl/SNRT, 26 Electronics Parkway, Rome, NY 13441-4514, US; no later than December 31, 2006.

WARREN D. WHITE AWARD FOR EXCELLENCE IN RADAR ENGINEERING

Nominations Wanted

Dana White Starr and Warren H. White established the Warren D. White Memorial Fund in 1999 and the Warren D. White Award to memorialize their father. The award, a plaque and honorarium, is to recognize an engineer who has made an outstanding achievement by contributing an advance (or series of advances) to radar engineering technology. The advance, significant, public, and well-known, shall be evidenced by technical papers, inventions, presentations, or products. Nominees need not be a member of IEEE or AESS. Nominations must allow appraisal of the candidate’s contribution(s). To enter a nomination, send a letter with three endorsements by the candidate’s peers, by February 15, 2007, to: Warren D. White Award, c/o Mark E. Davis, Box 176, Trenton Falls Road, Prospect, NY 13435-0176, USA; e-mail: mark.davis@rl.af.mil.

[Complete information about Warren D. White and the Award may be found in this publication, 15, 4 (April 2006), 2-3.]
Chapter News

Calling All Chapters
The Distinguished Tutorials Program

Sajjad H. Durrani

The Distinguished Tutorials Program (DTP) was first announced in the June issue of Systems. It is my great pleasure to report that several Sections have expressed considerable interest in it, and some are currently in touch with Distinguished Instructors (DIs) to schedule a tutorial.

To recap the concept:

The DTP allows a Section or an AESS Chapter to invite a DI to give a tutorial at no cost to the hosts. The AESS picks up the DIs travel cost and pays an honorarium; this allows our members to benefit from tutorials normally presented at major conferences, but are not available locally at a date convenient for the hosts.

The Program was approved by the AESS Board of Governors in April and we budgeted for two such Tutorials this year. Due to the better-than-expected response, we will try to obtain funds for three or more Tutorials in 2007. Similarly, the program started with five Tutorials, but four more have been added since. The current listing includes the DI’s topic, the DI’s name, affiliation, and e-mail addresses.

Automated Testing
Michael Ellis, Northrop Grumman Corporation,
mtellis@aol.com

GPS and Inertial Data Processing
James Farrell, VIGIL, Inc.,
navaide@comcast.net

Systems Approach to Engineering Projects
Paul Gartz, Boeing Corporation,
p.gartz@ieee.org

Design and Use of Small Satellites in Education
Albert Helfrick, Embry Riddle Aeronautical University,
helfrica@erau.edu

Advances in Radar Technology
Robert Hill, Consultant,
janebobhill@msn.net

Navigation – Land, Air and Space
Myron Kayton, Consulting Engineer,
m.kayton@ieee.org

Space-Time Adaptive Processing for Surveillance Radar System
Michael L. Picciolo, SAIC,
Michael.J.Picciolo@saic.com

Digital Avionics
Cary Spitzer, Consultant,
c.spitzer@avionicon.com

Radar Reflectivity
Robert Trebits, Georgia Tech,
bob.trebits@gmail.com
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STANDING COMMITTEES & THEIR CHAIRS

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Awards – Erwin C. Gangl
  • M. Barry Carlton Award – Peter K. Willett
  • Harry Rowe Minnow Award – E.H. Hirt
  • Warren D. White Award – Mark Davis
  • Pioneer Award – Erwin C. Gangl
  • Judith Resnik IEEE Field Award – Erwin C. Gangl
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Fellow Search – Elliot L. Axelband
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History – Henry Oman
International Activities – Hugh D. Griffiths
Nominations – Paul E. Gartz
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Public Relations – James R. Huddle
Publications – Edward K. Reedy
  • Systems – Evelyn H. Hirt
  • Transactions – Peter K. Willett
Social Implications - Technical – Open
Standards – Arnold M. Greenspan
Strategic Planning – Paul E. Gartz
Student Activities – Jose R. Bolanos
Transnational Activities – Hugh D. Griffiths

IEEE REPRESENTATIVES (Other IEEE Entities)

IEEE Publications
  • IEEE Press – Russ J. Lefevre
  • Journal of Lightwave Technology – D. Chamin & M. Cardinale
  • Transactions on Pattern Analysis & Machine Intelligence – J.R. Harris
IEEE Organizational Units
  • Sensors Council – M. Wicks
  • IEEE-SA, IEEE SCC-20 Hardware Interfaces Sub-Committee (RPI and SATS Standards) – A. Greenspan
  • IEEE-USA, Communication & Information Technical Policy – Open
  • IEEE-USA, PACE – M. Cardinale
  • IEEE-USA, Research & Development Technical Policy – P. Holmer
  • IEEE-USA, Transportation & Aerospace Technical Policy – P. Holmer
  • PSPE Magazine Committee – Systems Editor-in-Chief – E.H. Hirt
  • PSPE Transactions Committee – Editor-in-Chief – P.K. Willett
  • Society on Social Implications of Technology – M. Cardinale

CONFERENCE LIAISONS

• IEEE Aerospace – M. Ruggieri & R.C. Rassa
• IEEE Autocetesto BoD – J. Chapman, W. Downing & D. Wallenbrecht
• IEEE International Carnahan Conf. on Security Technology – R.B. Trebits
• IEEE/AIAA Digital Avionics Systems Conf. – C.R. Spitzer & B.C. Breen
• All Radar Conferences – M.E. Davis
• IEEE Position, Location & Navigation Symposium – J.R. Huddle
• International Energy Conversion Engineering – G. Dukermani

LIAISONS TO NON-IEEE TECHNICAL SOCIETIES

• American Institute of Aeronautics & Astronautics (AIAA) – C.R. Spitzer
• Association of Old Crows (AOC) – E.C. Gangl
• French Institute of Navigation (SIN) – J.R. Huddle
• German Institute of Navigation (DGON) – J.R. Huddle
• Institution of Electrical Engineers (IEEE) Radar, Sonar & Navigation (RSN) Professional Networks (PN) – R.T. Hill
• Institute of Navigation (ION) – J.R. Huddle
• International Council on Systems Engineering (INCOSE) – G. Friedman

IEEE/AESS Website: http://www.eewh.ieee.org/aess
Please send corrections or omissions for this page to the Secretary
1. NAME AS IT SHOULD APPEAR ON IEEE MAILINGS: SEND MAIL TO: ☐ Home Address OR ☐ Business/School Address

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If yes, please provide, if known: MEMBERSHIP NUMBER

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3. BUSINESS / PROFESSIONAL INFORMATION

Company Name

Department / Division

Title / Position

Years in Current Position

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4. EDUCATION

A baccalaureate degree from an IEEE reference list of programs assures assignment of "Member" grade. For others, additional information and references may be necessary for grade assignment.

Baccalaureate Degree Received  Program / Course of Study

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State / Province  Country

Mo. / Yr. Degree Received

Highest Technical Degree Received  Program / Course of Study

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State / Province  Country

Mo. / Yr. Degree Received

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Index

**IEEE Aerospace & Electronic Systems Magazine**
(IEEE-AESM)

*IEEE Aerospace & Electronic Systems Magazine*, 21,
including *Tutorial III* is indexed in the following pages.

The IEEE Aerospace & Electronic Systems Society provides a combined
yearly index of all serial publications issued, including the
*IEEE Transactions on Aerospace and Electronic Systems* and
*IEEE Aerospace and Electronic Systems Magazine*.
The combined index, including any tutorials, appears in the
last issue of the transactions of the calendar year.

*Antecedent Charts* are to assist the identification and sequencing of references from, and
the (inter)relationship of, the IEEE/IRE/AIEE publications that constitute our heritage.

A *50 Year Cumulative Index of the Archival Periodical Publications*
of the society and its antecedents, spanning 1951-1999, was issued as
*IEEE Transactions on Aerospace and Electronic Systems*,

Included is a 1986-1999 cumulative index of the

Starting in 2004 the indexes of the two publications were combined.
To bridge between the *50 Year Cumulative Index* and 2004, indexing of
*IEEE Aerospace & Electronic Systems Magazine*, 15-18, 2000-2003,
followed the combined index in the transactions that year.

The magazine including the tutorials will continue to be indexed in its December
issue as well as being included in the combined index in the transactions.

*Tutorial II* is Part 2 of *IEEE A&E Systems Magazine*, 20, 8, August 2005
*Tutorial III* is Part 2 of *IEEE A&E Systems Magazine*, 21, 6, July 2006

Some conferences were included and indexed in the transactions in the 1960s-1970s.
For the totality of all of the publications of this society, there must be availability and
accompanying indexing of conferences held under the auspices of our "family tree."
This is currently being investigated.
Society Ancestry within IEEE

IEEE Aerospace & Electronic Systems Society

IEEE changed the naming of all groups to societies in January 1973

IEEE Aerospace & Electronic Systems Group

July 1, 1965
(Dates indicate formalization of entity.)

IEEE Aerospace Group 1963
IEEE Military Electronics Group 1963
IEEE Space Electronics & Telemetry Group 1963
IEEE Aerospace & Navigational Electronics Group 1963

AIEE and IRE merged into the IEEE January 1, 1963

AIEE Aerospace Group 1962
IRE Military Electronics Group 1957
IRE Space Electronics & Telemetry Group 1959
IRE Aerospace & Navigational Electronics Group 1961

AIEE Aerospace Instrumentation Committee 1956
AIEE Flight Test Instrumentation Subcommittee of the Instrumentation and Measurements Committee (Unknown)
IRE Telemetry & Remote Control Group 1954
IRE Aeronautical & Navigational Electronics Group 1953

AIEE Air Transportation Committee 1940
IRE Radio Telemetry & Remote Control Group 1954
IRE Airborne Electronics Group 1951
Antecedents of AES Magazine

IEEE Aerospace and Electronic Systems Magazine *
(AES-M)

IEEE Aerospace & Electronic Systems Magazine
ISSN: 0885-8985/OCLC: 12760485
Coden: IESMEA
Vol. 1, no. 1 - (Jan. 1986 - Present)

IEEE Aerospace and Electronic Systems Society Newsletter*
[*note: Articles included in this publication]

S - AES Newsletter
[Aerospace & Electronic Systems Society Newsletter]


G- AES Newsletter
[Group on Aerospace & Electronics Systems]
Vol. 1, no. 1 – Vol. 8, no. 2 (July 1965 – Feb 1973)

Effective July 1, 1965, the Aerospace and Electronic Systems (AES) Group was formed by the merger of the Military Electronics, Aerospace & Navigational Electronics, Space Electronics & Telemetry and Aerospace Groups.

MIL-E-GRAM

Monthly newsletter of the Military Electronics Group of the Institute of Electrical and Electronics Engineers
(Vol. 5, no.1 - Vol. 7, no. 10 (Jan 1963 – June 1965)

Monthly newsletter of the Military Electronics Group of the Institute of Radio Engineers

* At the present time, information about newsletters of the Aerospace & Navigational Electronics and Space Electronics & Telemetry Groups prior to the July 1, 1965 merger is not available. The Aerospace Group included its News & Information within its Transactions, which are referenced in the 50th Year Cumulative Index.

Sources:
- David B. Dobson (LSM), Amin. Editor, IEEE AESS

Compiled by: E. Moscara, Sr. Information Analyst, IEEE
Last updated: 21-October 2005
This chart, giving the ancestry and evolution of this journal, is provided to assist in the proper identification and sequence of references in articles herein. It is also in response to those inquiring into the (inter) relationship of various IEEE/IRE/AIESS titles.

Sources:
- David Dobson (LSM), IEEE AES Society
- Worldcat (OCLC)

Compiled by: E. Moscara, Senior Information Analyst, IEEE

Last Updated: 2 Nov. 2004
This index covers all technical items — papers, correspondence, reviews, tutorials, special publications, etc. — that appeared in this periodical during 2006, and items from previous years that were commented upon or corrected in 2006. Departments and other items may also be covered if they have been judged to have archival value.

The Author Index contains the primary entry for each item, listed under the first author’s name. The primary entry includes the coauthors’ names, the title of the paper or other item, and its location, specified by the publication abbreviation, year, month, and inclusive pagination. The Subject Index contains entries describing the item under all appropriate subject headings, plus the first author’s name, the publication abbreviation, month, and year, and inclusive pages. Subject cross-references are included to assist in finding items of interest. Note that the item title is found only under the primary entry in the Author Index.

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