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Son of Submarine Game

. . . an alternative to chess?

Pete Stark's SR-52 game program "Submarine" originally appeared in issue #2 of Kilobaud *and has since become one of the most popular games played on that calculator. Ed and John call their version "Son of Submarine" and they have some modifications which make the game even better. Enjoy. — John.*

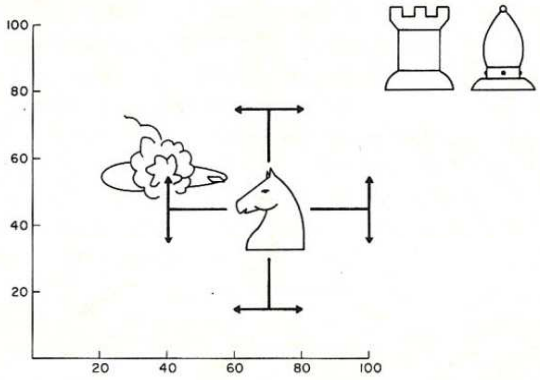


Fig. 1. Game layout.

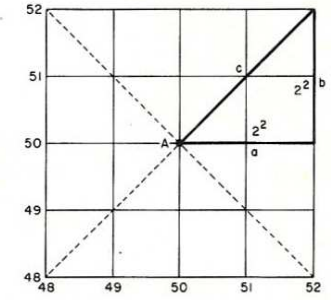
The game "Submarine" in issue #2 of *Kilobaud* by Peter Stark was most interesting, and I lost no time in entering the program into my SR-52 to try it out. However, after playing the game awhile I felt that something was missing. There wasn't the same enjoyment as playing the lunar landing game from Texas Instruments' (TI) program book. So I asked my coauthor to try the game and he came to somewhat the same conclusion. First, the game was very cleverly conceived. But after you get within five miles of the sub (which can be accomplished quickly by triangulation), the odds are 1 in 100 of selecting the proper locations on the next try since the sub will have moved randomly to a new location somewhere within a 100 square mile area. We felt that this game needed a small addition to allow the player to use logic in choosing his shot.

After examining the flowchart and trying a few variations, we discovered a simple addition which would still save the random motion realism of a submarine under attack but would allow the player to use his knowledge of mathematics and logical thinking ability to make the game more interesting. After all, one of the most interesting aspects of computed games is the satisfaction of being able to match logical wits with the computer and possibly get a step up and win.

Now with the changes made to the original submarine game the following scenario applies.

An enemy submarine has been spotted near one of your ports, its exact location unknown. To destroy it, place a 100 x 100 grid of graph paper over a map of the suspected area as shown in Fig. 1, and drop depth charges at specified points, using the X and Y coordinates to keep track of their location. *Each time you fire, the submarine moves to a new location. Sonar and other classified equipment then pick up an echo from the submarine and tell you the distance to its new position.*[1] Of course, as soon as you start firing, the submarine starts to zigzag in an effort to escape. The sub can go anywhere in the square as well as up or to the right of it, though it cannot go left or down into negative X and Y coordinates — since this would bring it too close to shore. The submarine can be put out of commission only by a direct hit (signalled by flashing lights of the calculator). If you miss by a distance of five or less, you only inflict minor damage; the submarine can tolerate up to five minor hits, but on the fifth minor hit it puts on a great burst of speed to get to a new location so repairs can be made. To play the game, proceed as follows:

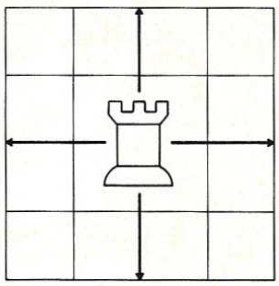
1. Push the C button to start the game.
2. Enter the X coordinate for your depth charge; push A.
3. Enter the Y coordinate for your depth charge; push B.
4. If you hit the sub, the display will flash, otherwise



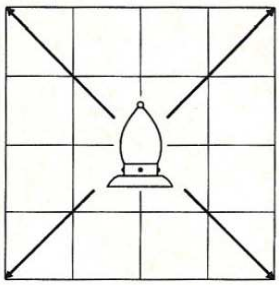
A = Position of last shot.
Display of distance = 2.83
$a^2 + b^2 = c^2$
$a^2 + b^2 = 8 = 2.83^2$
$c = 2.83$

Fig. 2.

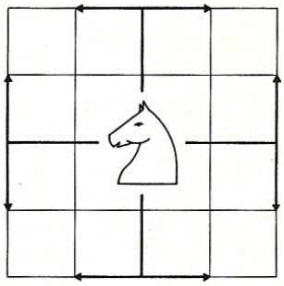
[1] The original submarine game provided the distance by which the players shot missed the submarine at its old location. It is the providing of the distance to the new submarine position that is the basis for Son of Submarine Game.



The Castle may move any open distance along a vertical or horizontal row of squares (on a standard checkerboard).



The Bishop may move any open distance along a diagonal.



The Knight's move is an L shaped move of two up and one over in any one of the four basic (up, down, left, right) directions, allowing eight possible locations to be reached.

Fig. 3.

DISTANCE FROM SUB	CHESS PIECE	SPACES MOVED	PROBABILITY OF SUCCESS
1.00	CASTLE	ONE	25%
1.41	BISHOP	ONE	25%
2.00	CASTLE	TWO	25%
2.24	KNIGHT	TWO & ONE	12 1/2%
2.83	BISHOP	TWO	25%
3.00	CASTLE	THREE	25%
3.16	MODIFIED KNIGHT	THREE & ONE	12 1/2%
3.61	MODIFIED KNIGHT	THREE & TWO	12 1/2%
4.24	BISHOP	THREE	25%
4.00	CASTLE	FOUR	25%
4.12	MODIFIED KNIGHT	FOUR & ONE	12 1/2%
4.47	MODIFIED KNIGHT	FOUR & TWO	12 1/2%
5.00	CASTLE & MODIFIED KNIGHT	FIVE OR FOUR & THREE	8 1/3%

Table 1.

the display will indicate the distance to the new sub position. (Note: Under the new scenario you know the distance to the new submarine location instead of the old position.)

The fact that the player may get off a shot at the current submarine position opens up a whole new group of possibilities which enables the player to cut down on the odds against him.

By using the Pythagorean theorem (the square of the hypotenuse of a right triangle is equal to the sum of the squares of the legs, or $c^2=a^2+b^2$) the player may determine all possible locations of the sub corresponding to the displayed distance. Fig. 2 shows the four possible locations (48, 48); (52, 48); (48, 52); (52, 52) for a displayed distance of 2.83 from (50, 50). All possible locations for display distances up to five have been calculated and are provided in Table 1.

An interesting point noted during these calculations is that as one gets close to the sub the moves which provide the greatest probability of success are similar to the movements of pieces in the game of chess. The player need not concern himself with the game of chess in its entirety in order to use this technique, but rather needs only to understand the allowed movements of three of the higher ranking pieces of the game. These pieces and their corresponding movements are shown in Fig. 3.

In order to extend the chess move approach up to a displayed distance of five (the limit of the minor hit counter), it was necessary to define a move which we call the modified knight move (not allowed in the standard game of chess). The chess movements and corresponding display distances are provided in Table 1.

Let's see how these movements would look on a 100 x 100 grid. This will give us the information needed to apply these moves to obtain the best probability of tracking down the submarine.

Consider that the starting position of our move on the 100 x 100 grid is X = 50 and Y = 50 (50, 50). See Fig. 4.

Now the move of a knight is shown by move number 1, that is from (50, 50) to (51, 52) — a distance of $\sqrt{2^2 + 1^2}$. The number 2 move is that of a bishop, that is (50, 50) to (52, 52) — involving a distance of $\sqrt{2^2 + 2^2}$. The move of a castle is shown in move number 3, that is (50, 50) to (52, 50) — a distance of 2.

Now it must be realized that the bishop and the castle could stop at any position from (50, 50) to the end of

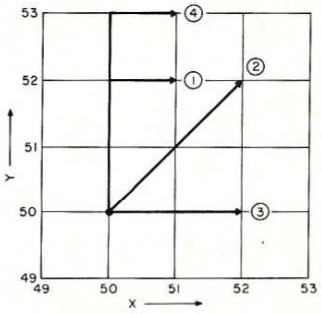
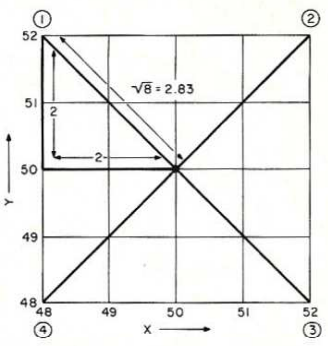


Fig. 4.



distance = $\sqrt{2^2 + 2^2} = 2.83$

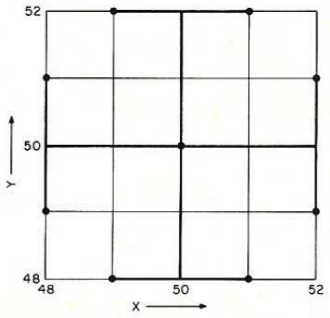
Fig. 5.

the grid. For example, a castle move from (50, 50) to (50, 100) is a move of 50 miles on our 100 x 100 mile grid.

Now a move from (50, 50) to (51, 53) – move number 4 – is not a proper move on a chessboard, but is a modified form of the knight's move with the same number of possible moves as that of a knight (eight moves).

Now let's try out this new-found knowledge on the Son of Submarine game (see Fig. 5).

For example, if we have just fired at the location X = 50, Y = 50 (50, 50) and the calculator answers back that we missed by 2.83 miles, there are only four different ways this could happen. That is if the sub is now at (48, 52); (52, 52); (52, 48); (48, 48). These are the only possible combinations that the SR-52 could compute 2.83 or $\sqrt{2^2 + 2^2} = \sqrt{8} = 2.83$. This is the move of a bishop. The possibility of a hit is one out of 4 or 25%.



(49, 52) (51, 52) (52,51) (52, 49) (51, 48) (49,48) (48, 49) (48, 51)

Fig. 6.

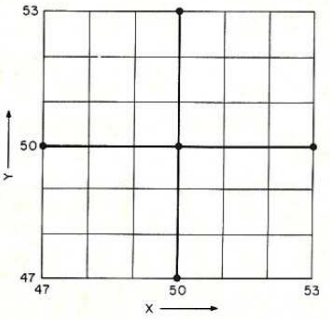


Fig. 7.

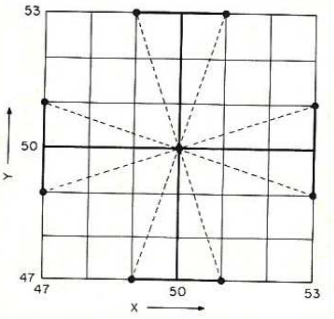


Fig. 8.

Refer to Fig. 6. Again we have just fired at location (50, 50). The missed distance is displayed by the computer as 2.24 or $\sqrt{2^2 + 1^2} = \sqrt{5} = 2.24$. There are only eight different ways this could happen. And that is if the submarine is at (49, 52); (51, 52); (52, 51); (52, 49); (51, 48); (49, 48); (48, 49); (48, 51). These are the only possible combinations that give the distance 2.24 miles from (50, 50) and these eight moves are the moves that a knight can make in a chess game.

In the example in Fig. 7 we have just fired at location (50, 50). The missed distance is displayed by the computer as 3 or $\sqrt{3^2 + 0^2} = \sqrt{9} = 3$. There are only four different ways that this could happen, and that is if the submarine is at (50, 53); (53, 50); (50, 47); (47, 50). These are the only combinations that give a three mile distance from (50, 50) and are the moves that a castle can make.

In Fig. 8 we once again consider that we are firing at location (50, 50) and we are given a 3.16 mile distance to the sub by the computer. There are only eight ways that we could be 3.16 miles away from the sub: (49, 53); (51, 53); (53, 51); (53, 49); (51, 47); (49, 47); (47, 49); (47, 51). These are the only combinations that give a 3.16 mile distance. This is a modified knight's move.

Now I think you can see that once we get within five miles of the submarine we can use our knowledge of mathematics to logically deduce the move which will give the best probability of a hit.

Before trying to use Table 1 to pursue and sink the submarine, let's summarize. Once within a five mile range, before choosing a location to fire on, you will always be able to find the chess move that will give you the greatest probability of success. Just take the distance given by the SR-52 and enter the distance column; when the numbers match, read across to the right for the choice of moves which give the greatest probability of success. For example, 2.83 is found to be a bishop's move. The choices you have for a hit are your original location (X, Y) adjusted for the two-step bishop move.

So, to sum up the game as modified, the player must first get close to the submarine and then based on the distance, make one of the chess moves which will give him the greatest probability of success. If he misses after five near-shot tries (if all attempts were within five miles), the sub will make a quick maneuver to a distant location. He must get close to the sub and try again. For those who are students of probability, you may note the best five-guess combination would be for five 25% chances before the submarine moves, which is $100\ [1-(1-.25)^5] = 76\%$. The probability of success for the original submarine program is $100\ [1-(1-.01)^5] = 5\%$.

Now go out there and get that submarine! ■

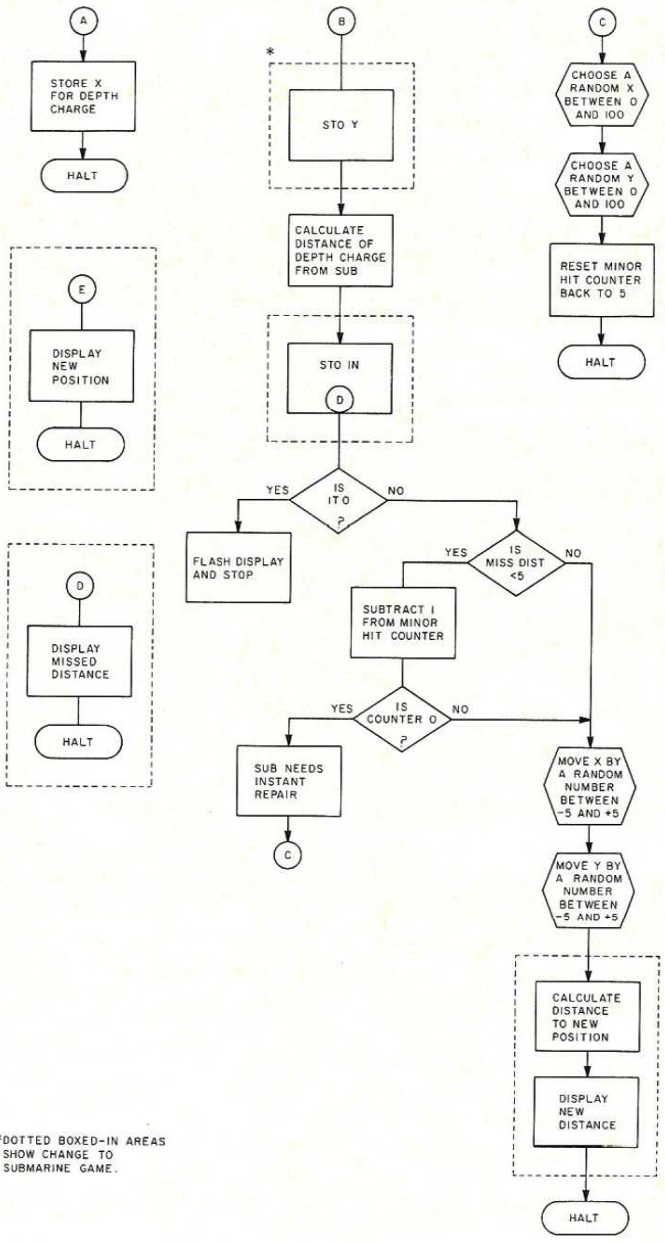


Fig. 9. Son of Submarine game flowchart.

Location	Comments	Instructions
000	Label A	Enter X value for depth charge
002	STO 05	Store it in register 5
005	Halt	Stop and wait for Y value
006	Label B	Enter Y value for depth charge
*008	STO 06	
011	- RCL 02	
015	$X^2\sqrt{X}$ =	
118	X^2	
119	+ (RCL 05 - RCL 01	
028	$X^2\sqrt{X}$)	
031	X^2 =	Compute distance by which the depth charge missed
033	$\sqrt{X}$	
*034	STO 07	Store missed distance
037	inv if zero =	If zero flash display and stop
040	0 1/X Halt	If not zero . . .
043	Label =	
045	- 5 =	Compare missed distance with 5
048	if pos +	If less than 5 subtract 1 from
050	inv dsz C	Minor hit counter and go to C if counter has reached 0; otherwise continue
053	Label +	
055	subr 1'	Get a small random number . . .
057	sum 01	. . . and move sub sideways
060	subr 1'	Get another small random number
062	sum 02	and move up or down
*065	RCL 06	
*068	- RCL 02	
*072	$X^2\sqrt{X}$ =	
*075	X^2	Compute new position of
*076	+ (RCL 05 - RCL 01	submarine and store
*085	$X^2\sqrt{X}$)	
*088	X^2 =	
*090	$\sqrt{X}$	
*091	STO 04	
094	RCL 04	Displayed new sub position
097	Halt	and stop
098	Label C	Reset
100	subr 8'	Get big random number for
102	STO 01	X and Y and move
105	subr 8'	
107	STO 02	
110	5 STO 00	Reset minor hit counter to
114	Halt	and stop
115	Label 1'	Start of subroutine to get a
117	5 +/-	small number between -5
119	+ .10 X	and + 5
124	Label 8'	Start of subroutine to get
126	100 x (($7Y^X9$	a big random number between
135	X RCL 03	0 and 100
139	X 5 +/- INV LOG)	
145	- (RCL - .5)	Shuffle number around to
152	FIX 0 DMS INV FIX)	make them seem random
158	STO 03 =	
162	FIX 0 DMS INV FIX	
*167	FIX 2	
169	return	End of both subroutines
*170	Label D	Recall missed distance of last shot
*172	RCL 07	
*175	Halt	
*176	Label E	Recall present distance to
*178	RCL 04	new sub position
*181	Halt	

*New additions to submarine program

Program listing.