CROSSWORD CONSTRUCTION BY COMPUTER

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In the November 1980 Word Ways, I briefly described a computer program designed by Lawrence J. Mazlack to place letters one at a time in a specified crossword grid until all vertical and horizontal slots are filled by words in a stored dictionary. Even though his test grids were very simple (the largest one, a 13-by-13, contained 30 per cent blank squares, 7 per cent unchecked letters, and no words of more than four letters), the program did not always succeed in fully filling them with words. More dismaying, Mazlack’s program completely failed to find a double word square of size 4-by-4, although this may have been due to a limited vocabulary size (2000 words).

I recently learned of two other researchers who have tackled the crossword construction problem with considerably greater success: P. D. Smith and S. Y. Steen published "A Prototype Crossword Compiler" in The Computer Journal (1981), and O. Feger published "Ein Programm zur Konstruktion von Kreuzworträtseln" in Angewandte Informatik (1975). Their success is apparently due to two factors: (1) larger vocabulary stored in the computer (Smith and Steen 7869 words of lengths 2 - 17, Feger about 10000 words of lengths 3 - 8), (2) a construction algorithm which fills in words one at a time rather than letters one at a time. The ingenuity of their programs lies in the order in which successive word slots (starting with one hand-filled slot to prime the pump) are selected to be filled. Briefly, the strategy is to tackle the more difficult word slots (those that have the fewest alternatives in the dictionary) first. Usually, this means that longer slots are filled first, but if a slot is partially filled in with letters from crossing words, its alternatives may be so reduced that it is promoted to the head of the queue. If, in a sequence of such decisions, the computer is unable to fill a word slot from the dictionary, it backs up and tries another word in an earlier slot.

In the table below, I summarize the results of a number of computer runs by both authors.

<table>
<thead>
<tr>
<th>Feger</th>
<th>Per Cent of Squares that are Blank</th>
<th>Per Cent of Squares that are Unchecked</th>
<th>Per Cent of Squares that are Checked</th>
<th>Time (secs.)</th>
<th>Longest Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 x 10</td>
<td>15</td>
<td>10</td>
<td>75</td>
<td>8.39</td>
<td>8</td>
</tr>
<tr>
<td>9 x 11</td>
<td>27</td>
<td>12</td>
<td>61</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>10 x 12</td>
<td>14</td>
<td>8</td>
<td>78</td>
<td>43</td>
<td>7</td>
</tr>
</tbody>
</table>

How clues work with blank squares

However, magazines are stituated by the restriction, 1 unchecked clue.

In the completed puzzle, the computer will be confronted with several

From its dictionary, it will try to

...
The first three Smith and Steen puzzles were based on crossword grids actually published in British newspapers of May 1980 (Daily Record, Daily Telegraph, Guardian); a typical puzzle is given below.

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R E S T R I C T I N G
A H S A E A R E A
E S T A B L I S H E D O R
Y T A K D S P I N
I S N I O
R E C O R D S I N F O R M S
O A S W I N G T
N I N E O D S I G N
M D T O P I C O E
O P I N I O N A L M O N D S
N B I S S
G E A R A S M V O
E V O C C U P A T I O N S
R A I L C N T S C
Y A C O N G R E G A T E D
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How close are computers to producing crossword puzzles found in magazines and newspapers? If it is possible for cryptic clue-weavers to work with any words presented to them, then they are very close indeed. However, I suspect that this is not the case, and that the higher percentages of blank squares and unchecked letters in British puzzles are necessitated by the fact that many words don't lend themselves to clever cryptic clues. In American puzzles, any word can be clued; however, good puzzles typically have no more than 17 per cent blank squares and no unchecked letters. A few of Feger's small puzzles achieve the first restriction, but none satisfy the second; it would be most interesting to see what happens to the computer running time if either program were confronted with a typical American grid. In view of the wide variation in running time, the program should be instructed to pick start words at random from its dictionary, trying a fresh starter if one does not obtain a completed puzzle in (say) one minute. Finally, it would be useful if the program could deal with multiple start words scattered throughout the grid to accommodate thematic crossword puzzles.