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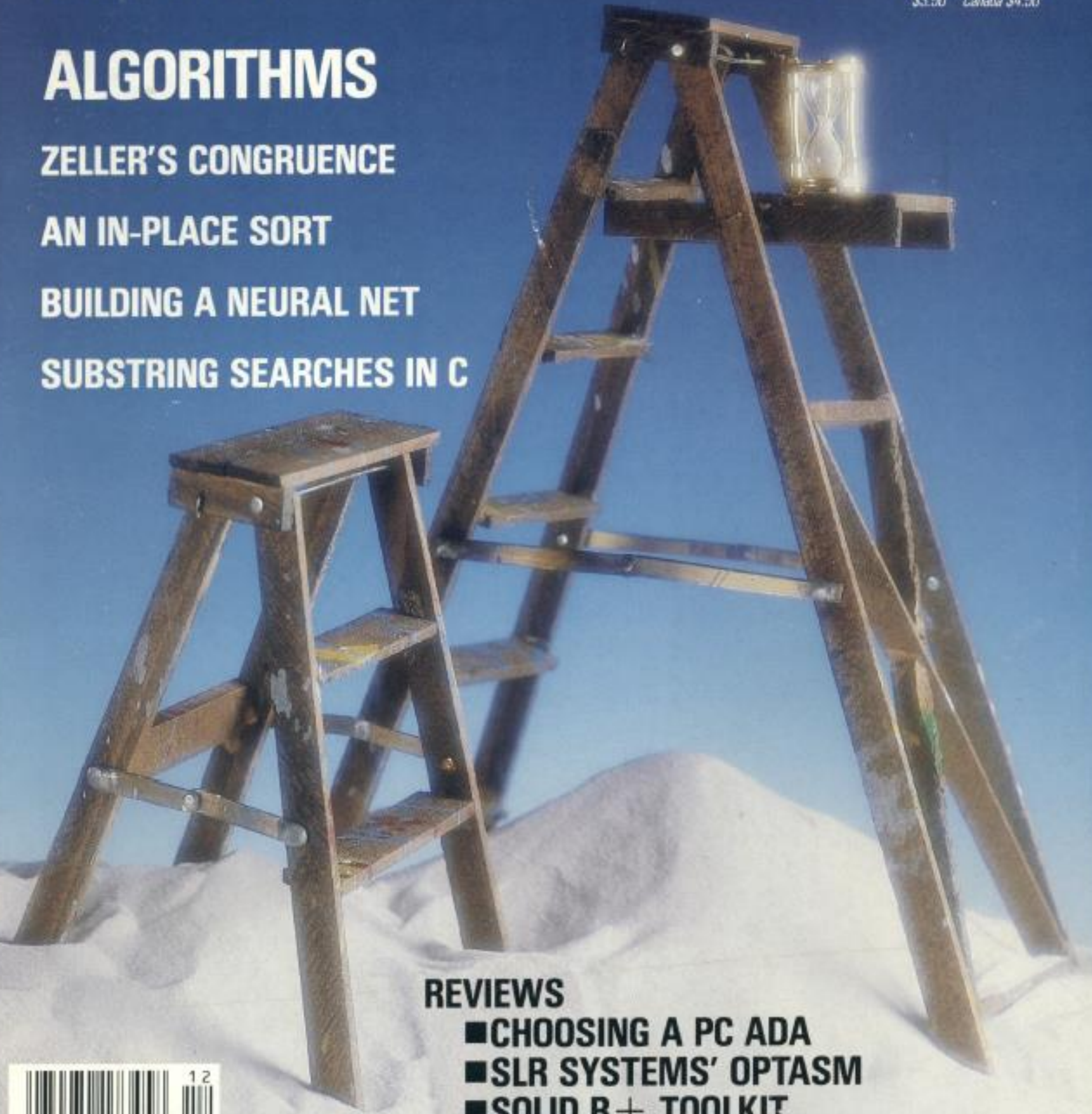
ALGORITHMS

ZELLER'S CONGRUENCE

AN IN-PLACE SORT

BUILDING A NEURAL NET

SUBSTRING SEARCHES IN C

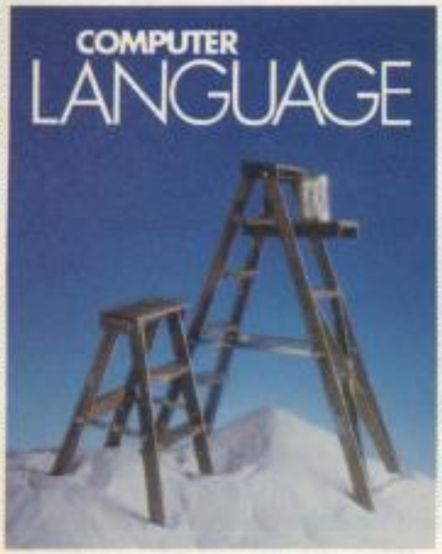


REVIEWS

- CHOOSING A PC ADA
- SLR SYSTEMS' OPTASM
- SOLID B+ TOOLKIT

CONTENTS

DECEMBER 1988



Cover Art: *Did you know that "algorithm" is derived from* al-Khuwarizmi, *the name of a ninth-century Arabic mathematician? And "ladder" comes from the Latin* clinare *("to lean"), with stops along the way in Greek, Old High German, and Old English.*

Articles

Product Reviews

Departments

String Searching in C

This APL-style algorithm locates substrings within character strings

Sanford J. Hersh

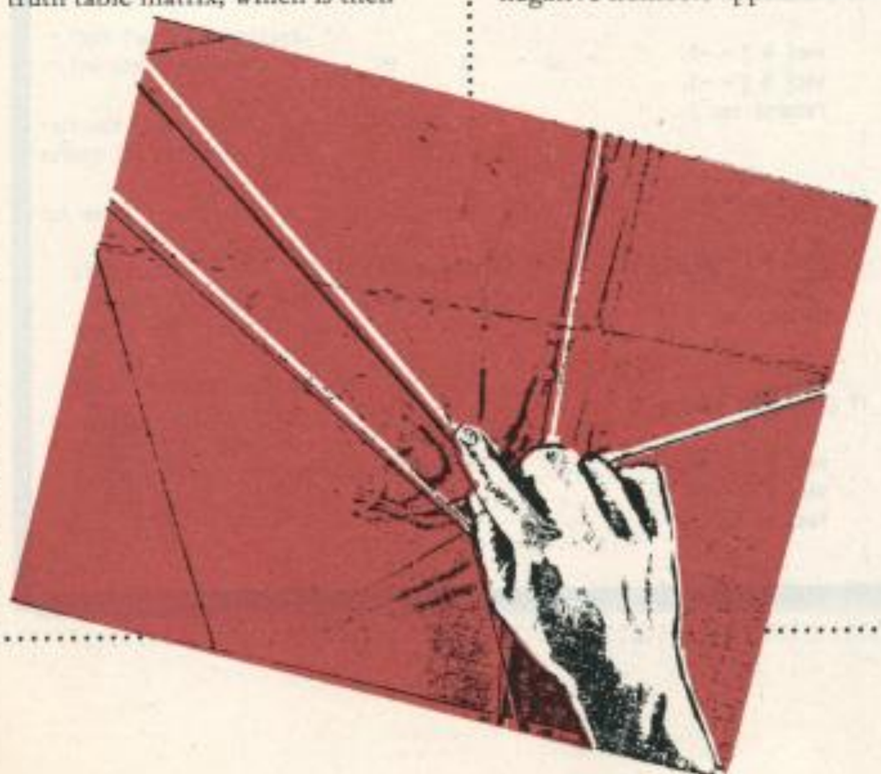
C is a language that should make string manipulation easy. Unfortunately, it typically does not include commands to do substring searching. How many occurrences of a substring are within a string and where are they? This article presents an algorithm that addresses this question.

This routine (Listing 1) is based somewhat on the technique that would be used to solve the same problem in APL (Listing 2). The major difference is that in APL, all tests are made first to produce a truth table matrix, which is then shifted and compressed to a vector. In this C routine, a truth table vector is built. Each succeeding test result is shifted and then overlays the vector. In both cases, the resulting vector is used to produce position integers.

The function *STRSRCH* returns a pointer to an integer vector that is terminated by a negative one. Any positive integer before this terminator is a position of the substring within the string. To find out how often this substring occurs within the string, these numbers simply need to be counted. If any negative numbers appear before the terminating negative one, a failure occurred during boundary checking.

The program starts with five *if* statements that do nothing more than make boundary checks. The heart of the algorithm is contained within the next three *for* loops. The first one creates the initial truth table vector. The second overlays all the others over it. The third converts this vector into positions.

The maximum number of positions is arbitrarily defined by *sizvec*. This number can be changed at the whim of the programmer. Listing 3 (*STRTEST*) is an example of how this program is used. ■



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Artwork: Dwight Been

LISTING 1. (Continued on following page)

```
/* This C program is based on the following APL program: */

/*    $
[0]  VEC #is STRING STRSRCH SUBSTG;#io;ARY
[1]  | returns all positions of SUBSTG within STRING
[2]   #io #is 0
[3]   STRING #is.STRING & SUBSTG #is.SUBSTG
[4]   ARY #is #and/(#iota #rho SUBSTG)#theta STRING #outer=SUBSTG
[5]   VEC #is ARY/#iota #rho STRING
      $        */

/* STRSRCH returns a pointer to an integer vector that terminates with -1.
 Any positive number preceding the -1 is a position of the substg
 within the string. A negative number preceding the -1 represents an error. */

typedef char * char_ptr;
#define sizvec 15
#define NOMEM  ( char_ptr )0

int  *strsrch( string, substg )
char_ptr string, substg;
{
   register int x, y;
   static int vec[ sizvec + 1 ];   /* leave room for -1 */
   unsigned int sizstg, sizsub, endsiz, *ary;
   char_ptr startmem, malloc( );
   int strlen( );

   sizstg = strlen( string );
   sizsub = strlen( substg );
   endsiz = sizstg - sizsub + 1;

/* Check boundary conditions: */

   if ( ( sizstg == 0 ) && ( sizsub == 0 ) )
   {
       vec[ 0 ] = -5;
       vec[ 1 ] = -1;
       return( vec );
   }

   if ( sizsub == 0 )
   {
       vec[ 0 ] = -3;
       vec[ 1 ] = -1;
       return( vec );
   }

   if ( sizstg == 0 )
   {
       vec[ 0 ] = -2;
       vec[ 1 ] = -1;
       return( vec );
   }

   if ( sizsub > sizstg )
   {
       vec[ 0 ] = -6;
       vec[ 1 ] = -1;
       return( vec );
   }
```

LISTING 1. (Continued from preceding page)

```
    if ( NOMEM == ( ary = startmem = malloc( endsiz * sizeof( int ) ) ) )
    {
        vec[ 0 ] = -9;
        vec[ 1 ] = -1;
        return( vec );
    }

/* Start of algorithm: */

    for( x = 0; x < endsiz; x++ )
        *ary++ = string[ x ] == substg[ 0 ];

    for( y = 1, ary = startmem; y < sizsub; y++, ary = startmem )
        for( x = y; x < ( endsiz + y ); x++ )
            *ary++ &= string[ x ] == substg[ y ];

    for( y = 0, x = 0; ( x < endsiz ) && ( y < sizvec ); x++ )
        if ( *ary++ )
            vec[ y++ ] = x;

    vec[ y ] = -1;
    free( startmem );
    return( vec );
}
```

LISTING 2.

```
      ∇STRSRCH[⎕]∇
[0]   VEC←STRING STRSRCH SUBSTG;⎕IO;ARY
[1]   ⍝ RETURNS ALL POSITIONS OF <SUBSTG> WITHIN <STG>
[2]    ⎕IO←0
[3]    STRING←,STRING ◇ SUBSTG←,SUBSTG
[4]    ARY←∧/(⍳⍴SUBSTG)⊖STRING∘.=SUBSTG
[5]    VEC←ARY/⍳⍴STRING
```

LISTING 3.

```
/* This function displays: */
/* The positions are:   4     29     51     82  */

#include <stdio.h>
extern int *strsrch( );

int main( )
{
    static char *stg1 = "The files are located in the file cabinet.
      Please file this memo in the circular file!";
    static char *stg2 = "file";
    int *ptr;
    ptr = strsrch( stg1, stg2 );
    printf( "The positions are:\t" );
    while( -1 != *ptr )
        printf( "%d\t", *ptr++ );
    printf( "\n" );
    return( 0 );
}
```