Citation for published version

DOI
https://doi.org/10.1145/569147.569153

Link to record in KAR
http://kar.kent.ac.uk/13727/

Document Version
UNSPECIFIED

Copyright & reuse
Content in the Kent Academic Repository is made available for research purposes. Unless otherwise stated all content is protected by copyright and in the absence of an open licence (eg Creative Commons), permissions for further reuse of content should be sought from the publisher, author or other copyright holder.

Versions of research
The version in the Kent Academic Repository may differ from the final published version. Users are advised to check http://kar.kent.ac.uk for the status of the paper. Users should always cite the published version of record.

Enquiries
For any further enquiries regarding the licence status of this document, please contact: researchsupport@kent.ac.uk
If you believe this document infringes copyright then please contact the KAR admin team with the take-down information provided at http://kar.kent.ac.uk/contact.html
Remark on Algorithm 705: A Fortran-77 Software Package for Solving the Sylvester Matrix Equation

\[ AXB^T + CXD^T = E \]

Tim Hopkins

University of Kent

We present a number of corrections to Algorithm 705 [Gardiner et al. 1992].

The following problems were encountered in Algorithm 705 when the source code was being tested as part of the project to bring all the CALGO algorithms that have appeared in ACM TOMS to a consistent level of quality [Hopkins 2002].

The statements provided when updating the 2 × 2 submatrix for the case when \( I = K \) and \( J0B = 1 \) are incorrect in both the routines BKCON and BKBLS. In each case, where the linear system solved is of order 3, element 4 of the approximation to the null vector returned by the Linpack [Dongarra et al. 1979] routine DGECO is accessed when it has not been assigned a value.

In BKCON in the IF block guarded by

\[
\text{IF (DOSEP) THEN}
\]

following the statement

\[
\text{NSYS} = 3
\]

replace

\[
\text{TMP} = R(K,K)*E(1) + R(K,K-1)*E(2) + R(K-1,K)*E(2) + R(K-1,K-1)*E(4)
\]

by

\[
\text{TMP} = R(K,K)*E(1) + R(K,K-1)*E(2) + R(K-1,K)*E(2) + R(K-1,K-1)*E(3)
\]

Address: Computing Laboratory, University of Kent, Canterbury, Kent, CT2 7NF, UK.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or direct commercial advantage and that copies show this notice on the first page or initial screen of a display along with the full citation. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, to redistribute to lists, or to use any component of this work in other works, requires prior specific permission and/or a fee. Permissions may be requested from Publications Dept, ACM Inc., 1515 Broadway, New York, NY 10036 USA, fax +1 (212) 869-0481, or permissions@acm.org.
In `BKDIS` in a similar position replace
\[
\text{TMP} = R(K,K) * E(1) + R(I,K-1) * E(2) \\
  \quad + R(K-1,K) * E(3) + R(K-1,K-1) * E(4)
\]
by
\[
\text{TMP} = R(K,K) * E(1) + R(K,K-1) * E(2) \\
  \quad + R(K-1,K) * E(3) + R(K-1,K-1) * E(3)
\]
and
\[
R(K-1,K) = R(K-1,K) + \text{TMP} * E(3)
\]
\[
R(K-1,K-1) = R(K-1,K-1) + \text{TMP} * E(4)
\]
by
\[
R(K-1,K) = R(K-1,K) + \text{TMP} * E(2)
\]
\[
R(K-1,K-1) = R(K-1,K-1) + \text{TMP} * E(3)
\]

There are also problems in the routines `HSCO` and `HSSL` where calls to the BLAS [Lawson et al. 1979] routines `DDOT` and `DAXPY` cause array accesses outside of the range of the actual vector arguments. To prevent these illegal, out of bounds, assignments taking place:

in the routine `HSCO` replace the statement in the DO 120 block
\[
\text{IF (K .LT. N) Z(K) = Z(K) + DDOT(SD, AV(I1+1), 1, Z(K+1), 1)}
\]
by
\[
\text{IF (K .LT. N)}
\]
\[
+ Z(K) = Z(K) + DDOT(MIN(SD, N-K), AV(I1+1), 1, Z(K+1), 1)
\]
and replace the statement in the DO 140 block
\[
\text{IF (K .LT. N) CALL DAXPY(SD, T, AV(I1+1), 1, Z(K+1), 1)}
\]
by
\[
\text{IF (K .LT. N)}
\]
\[
+ \text{CALL DAXPY(MIN(SD, N-K), T, AV(I1+1), 1, Z(K+1), 1)}
\]
Similarly in the DO 20 block in the routine `HSSL` replace
\[
\text{CALL DAXPY(SD, T, AV(I1+1), 1, B(K+1), 1)}
\]
by
\[
\text{CALL DAXPY(MIN(SD, N-K), T, AV(I1+1), 1, B(K+1), 1)}
\]
In the routine `BKHS2`, it is necessary to change the test immediately following label 110 from
\[
\text{IF (M.GT.1) THEN}
\]
to
\[
\text{IF (M.GT.1 .AND. J.NE.M) THEN}
\]
to avoid accessing row M+1 of the array P which is only required to be M by M.

The Fortran standard does not prescribe how the components of a compound relational expression should be evaluated. In particular it is not standard conforming to assume either left to right evaluation of subexpressions or short circuit evaluation (for example, only the first component of an 'and' is evaluated if it is found to be false). Thus the four statements of the form

```
IF (I .GT. 1 .AND. S(I,I-1) .NE. 0.0D0) GO TO label
```

that appear in routines BKCON and BKDIS (after labels 40 and 150 in both routines) should be replaced by

```
IF (I .GT. 1 ) THEN
  IF (S(I,I-1) .NE. 0.0D0) GO TO label
END IF
```

This is guaranteed to avoid the out of bounds array access to S(1,0) in the case of compilers that evaluate the right-hand subexpression.

In addition, it is possible to replace the declarations of all dummy arguments of length 1 in the routines BKCON, BKDIS, BWHS2, HSC0, HSFA, Q2HESG, QZITG, SEP, SEP1, SEP2, SYLG, SYLG0 and SYLG1 by expressions involving other dummy arguments (there is one exception, the workspace array WKV to SYLG, which needs to be assumed size).

Calls to the routine EPSLON used by Eispack [Hopkins and Slater 1993] to obtain a value for the machine epsilon were replaced with calls to the Port function D1MACH [Fox et al. 1978] both for efficiency and consistency reasons.

In the test driver programs array declarations were parameterized to make the codes easier to alter and to keep the reserved space down to an essential minimum. This helped to ensure that array bound violations were more likely to be detected by the compiler’s run-time system since the lengths of many of the workspace arrays were overestimated.

Finally, there are some minor pieces of clutter that may be removed from the code

1. the intrinsic functions DABS and DMAX1 do not need to be declared as double precision in the function D1NRM,
2. the variable INDXT0 is declared and initialized in both the routines SYLG0 and SYLG but is not referenced in either routine. All references to INDXT0 may thus be removed.
3. The label 100 in the routine QZVALG is never referenced and may be removed.
4. The replacement of all Hollerith constants by character constants.
5. The reliance by one of the test driver programs on the Unix random number generator has been removed. The driver program has been altered to use Schrage's portable random number generator [Schrage 1979]. This allows the software to be more easily ported to non-Unix platforms and also simplifies the comparison of results from different compiler/hardware combinations by ensuring a repeatable sequence.
REFERENCES


Hopkins, T. 2002. Renovating the collected algorithms from acm. ACM Transactions on Mathematical Software 28, 1, ???–???

