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# LAPACK routines (Linear Algebra PACKage)

## Blas *saxpy* routine level 1

Constant times a vector plus a vector.

$$\vec{y} = \alpha \cdot \vec{x} + \vec{y}$$

***Example 1:***

$\alpha = 2$

$\vec{x} = [4, 6, 1]$

$\vec{y} = [9, 7, 6]$

***Solving:***

$$\vec{y} = 2 \cdot [4, 6, 1] + [9, 7, 6] \implies \vec{y} = [8, 12, 2] + [9, 7, 6] \implies \vec{y} = [17, 19, 8]$$

$$\underline{\vec{y} = [17, 19, 8]}$$

***Code Output***

```
jj@pcerdo:~/Test$ g++ lapack.cpp -o lapack -lf77blas && ./lapack

Level 1 Blas saxpy routine:

SA: 2
SX: [ 4 6 1 ]
SY: [ 9 7 6 ]

y = a*x + y
Y: [ 17 19 8 ]
jj@pcerdo:~/Test$
```

### Blas *sgemv* routine level 2

Performs one of the matrix-vector operations

$$\vec{y} = \alpha \cdot A \cdot \overrightarrow{x^{\intercal}} + \beta \cdot \vec{y}$$

***Example 2:***

$\alpha = 3$

$\beta = 6$

$\vec{x} = [1, 3, 2]$

$\vec{y} = [2, 4, 1]$

$$A = \begin{bmatrix} 1 & 4 & 1 \\ 1 & 6 & 4 \\ 5 & 0 & 1 \end{bmatrix}$$

***Solving:***

$$\vec{y} = 3 \cdot \begin{bmatrix} 1 & 4 & 1 \\ 1 & 6 & 4 \\ 5 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 \\ 3 \\ 2 \end{bmatrix} + 6 \cdot [2, 4, 1] \implies \vec{y} = \begin{bmatrix} 3 & 12 & 3 \\ 3 & 18 & 12 \\ 15 & 0 & 3 \end{bmatrix} \cdot \begin{bmatrix} 1 \\ 3 \\ 2 \end{bmatrix} + [12, 24, 6] \implies$$

$\vec{y} = [57, 105, 27]$

$\underline{\vec{y} = [57, 105, 27]}$

***Code Output***

```
jj@pcerdo:~/Test$ g++ lapack.cpp -o lapack -lf77blas && ./lapack

Level 2 Blas segmv routine:

ALPHA: 3
BETA: 6
X: [ 1 3 2 ]
Y: [ 2 4 1 ]
A:
[ 1 4 1 ]
[ 1 6 4 ]
[ 5 0 1 ]

y = alpha*A*x+beta*y
Y: [ 57 105 27 ]
jj@pcerdo:~/Test$
```

### Blas *sgemm* routine level 3

Performs one of the matrix-matrix operations

$$C = (\alpha \cdot A \cdot B)^{\mathsf{T}} + \beta \cdot C$$

***Example 3:***

$$\alpha = 3$$

$$\beta = 6$$

$$A = \begin{bmatrix} 1 & 4 & 1 \\ 1 & 6 & 4 \\ 5 & 0 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 2 & 3 & 1 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix}$$

$$C = \begin{bmatrix} 5 & 2 & 2 \\ 1 & 7 & 4 \\ 1 & 4 & 1 \end{bmatrix}$$

***Solving:***

$$C = \left(3 \cdot \begin{bmatrix} 1 & 4 & 1 \\ 1 & 6 & 4 \\ 5 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 2 & 3 & 1 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix}\right)^{\mathsf{T}} + 6 \cdot \begin{bmatrix} 5 & 2 & 2 \\ 1 & 7 & 4 \\ 1 & 4 & 1 \end{bmatrix} \Longrightarrow C = \left(\begin{bmatrix} 3 & 12 & 3 \\ 3 & 18 & 12 \\ 15 & 0 & 3 \end{bmatrix} \cdot \begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix}\right.$$

$$C = \left(\begin{bmatrix} 27 & 72 & 18 \\ 60 & 111 & 33 \\ 39 & 48 & 18 \end{bmatrix}\right)^{\mathsf{T}} + \begin{bmatrix} 30 & 12 & 12 \\ 6 & 42 & 24 \\ 6 & 24 & 6 \end{bmatrix} \Longrightarrow C = \begin{bmatrix} 27 & 60 & 39 \\ 72 & 111 & 48 \\ 18 & 33 & 18 \end{bmatrix} + \begin{bmatrix} 30 & 12 & 12 \\ 6 & 42 & 24 \\ 6 & 24 & 6 \end{bmatrix}$$

$$C = \begin{bmatrix} 57 & 72 & 51 \\ 78 & 153 & 72 \\ 24 & 57 & 24 \end{bmatrix}$$

***Code Output***

```
jj@pcerdo:~/Test$ g++ lapack.cpp -o lapack -lf77blas && ./lapack

Level 3 Blas sgemm routine:

ALPHA: 3
BETA: 6
A:
[ 1 4 1 ]
[ 1 6 4 ]
[ 5 0 1 ]

B:
[ 2 3 1 ]
[ 1 5 1 ]
[ 3 1 1 ]

C:
[ 5 2 2 ]
[ 1 7 4 ]
[ 1 4 1 ]

C := alpha*op( A )*op( B ) + beta*C
C:
[ 57 72 51 ]
[ 78 153 72 ]
[ 24 57 24 ]
```

## Referencias

- LAPACK level 1 *saxpy* routine URL (http://www.netlib.org/lapack/explore-html/df /d28/group__single_blas_level1_gad2a52de0e32a6fc111931ece9b39726c.html)
- LAPACK level 2 *sgemv* routine URL (http://www.netlib.org/lapack/explore-html/d6 /d30/group__single_blas_level2_gafc92361b74c6d41c7e5afa0aa5d13ec9.html#gafc92361b74c6d41c7
- LAPACK level 3 *sgemm* routine URL (http://www.netlib.org/lapack/explore-html/db /dc9/group__single_blas_level3_gafe51bacb54592ff5de056acabd83c260.html#gafe51bacb54592ff5de0