Algorithm: $y := \text{MVMULT\_N\_UNB\_VAR1B}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where A_{TL} is 0×0, x_T, y_T are 0×1

while $m(A_{TL}) < m(A)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where α_{11}, χ_1, and ψ_1 are scalars

$$\psi_1 := a_{10}^T x_0 + \alpha_{11}\chi_1 + a_{12}^T x_2 + \psi_1$$

Continue with

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Mvmult_n_unb_var1B( A, x, y )

  [ ATL, ATR, ...
    ABL, ABR ] = FLA_Part_2x2( A, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( ATL, 1 ) < size( A, 1 ) )

    [ A00,  a01,     A02,  ...
      a10t, alpha11, a12t, ...
      A20,  a21,     A22 ] = FLA_Repart_2x2_to_3x3( ATL, ATR, ...
                                                    ABL, ABR, ...
                                                    1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    psi1 = laff_dots( a10t, x0, psi1 );
    psi1 = laff_dots( alpha11, chi1, psi1 );
    psi1 = laff_dots( a12t, x2, psi1 );
    %-------------------------------------------------------------%
    [ ATL, ATR, ...
      ABL, ABR ] = FLA_Cont_with_3x3_to_2x2( A00,  a01,     A02,  ...
                                             a10t, alpha11, a12t, ...
                                             A20,  a21,     A22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];
return
```

☛ Click to view .m file `Mvmult_unb_var1B.m`. ☛ Click for test script `test_Mvmult_unb_var1B.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{MVMULT\_N\_UNB\_VAR2B}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where A_{TL} is 0×0, x_T, y_T are 0×1

while $m(A_{TL}) < m(A)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where α_{11}, χ_1, and ψ_1 are scalars

$y_0 := \chi_1 a_{01} + y_0$
$\psi_1 := \chi_1 \alpha_{11} + \psi_1$
$y_2 := \chi_1 a_{21} + y_2$

Continue with

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Mvmult_n_unb_var2B( A, x, y )

  [ ATL, ATR, ...
    ABL, ABR ] = FLA_Part_2x2( A, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( ATL, 1 ) < size( A, 1 ) )

    [ A00,  a01,     A02,  ...
      a10t, alpha11, a12t, ...
      A20,  a21,     A22 ] = FLA_Repart_2x2_to_3x3( ATL, ATR, ...
                                                    ABL, ABR, ...
                                                    1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    y0   = laff_axpy( chi1, a01, y0 );
    psi1 = laff_axpy( chi1, alpha11, psi1 );
    y2   = laff_axpy( chi1, a21, y2 );

    %-------------------------------------------------------------%
    [ ATL, ATR, ...
      ABL, ABR ] = FLA_Cont_with_3x3_to_2x2( A00,  a01,     A02,  ...
                                             a10t, alpha11, a12t, ...
                                             A20,  a21,     A22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];
return
```

☛ Click to view .m file `Mvmult_unb_var2B.m`. ☛ Click for test script `test_Mvmult_unb_var2B.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{MVMULT\_T\_UNB\_VAR1}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_L & A_R \end{array} \right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array} \right)$$

where A_L is $m \times 0$ and y_T is 0×1

while $m(y_T) < m(y)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_L & A_R \end{array} \right) \rightarrow \left(\begin{array}{c|c|c} A_0 & a_1 & A_2 \end{array} \right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array} \right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array} \right)$$

where a_1 is a column

$\psi_1 := a_1^T x + \psi_1$

Continue with

$$\left(\begin{array}{c|c} A_L & A_R \end{array} \right) \leftarrow \left(\begin{array}{c|c|c} A_0 & a_1 & A_2 \end{array} \right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array} \right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array} \right)$$

endwhile

```
function [ y_out ] = Mvmult_t_unb_var1( A, x, y )

  [ AL, AR ] = FLA_Part_1x2( A, ...
                             0, 'FLA_LEFT' );

  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( AL, 2 ) < size( A, 2 ) )

    [ A0, a1, A2 ]= FLA_Repart_1x2_to_1x3( AL, AR, ...
                                           1, 'FLA_RIGHT' );

    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );

    %-------------------------------------------------------------%

    psi1 = laff_dots( a1, x, psi1 );

    %-------------------------------------------------------------%

    [ AL, AR ] = FLA_Cont_with_1x3_to_1x2( A0, a1, A2, ...
                                           'FLA_LEFT' );

    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );

  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Mvmult_t_unb_var1.m`. ☛ Click for test script `test_Mvmult_t_unb_var1.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{MVMULT\_T\_UNB\_VAR2}(A, x, y)$

Partition

$$A \rightarrow \left(\frac{A_T}{A_B}\right), \; x \rightarrow \left(\frac{x_T}{x_B}\right)$$

where A_T is $0 \times n$ and x_T is 0×1

while $m(A_T) < m(A)$ **do**

Repartition

$$\left(\frac{A_T}{A_B}\right) \rightarrow \left(\frac{A_0}{\frac{a_1^T}{A_2}}\right), \; \left(\frac{x_T}{x_B}\right) \rightarrow \left(\frac{x_0}{\frac{\chi_1}{x_2}}\right)$$

where a_1 is a row

$y := \chi_1 a_1 + y$

Continue with

$$\left(\frac{A_T}{A_B}\right) \leftarrow \left(\frac{A_0}{\frac{a_1^T}{A_2}}\right), \; \left(\frac{x_T}{x_B}\right) \leftarrow \left(\frac{x_0}{\frac{\chi_1}{x_2}}\right)$$

endwhile

```
function [ y_out ] = Mvmult_t_unb_var2( A, x, y )

  [ AT, ...
    AB ] = FLA_Part_2x1( A, ...
                         0, 'FLA_TOP' );

  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );

  while ( size( AT, 1 ) < size( A, 1 ) )

    [ A0, ...
      a1t, ...
      A2 ] = FLA_Repart_2x1_to_3x1( AT, ...
                                    AB, ...
                                    1, 'FLA_BOTTOM' );

    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );

    %------------------------------------------------------------%

    y = laff_axpy( chi1, a1t, y );

    %------------------------------------------------------------%

    [ AT, ...
      AB ] = FLA_Cont_with_3x1_to_2x1( A0, ...
                                       a1t, ...
                                       A2, ...
                                       'FLA_TOP' );

    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );

  end

  y_out = y;


return
```

☛ Click to view .m file `Mvmult_t_unb_var2.m`. ☛ Click for test script `test_Mvmult_t_unb_var2.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{TRMVP\_UN\_UNB\_VAR1}(U, x, y)$

Partition

$$U \rightarrow \left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where U_{TL} is 0×0, x_T, y_T are 0×1

while $m(U_{TL}) < m(U)$ **do**

Repartition

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & U_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where υ_{11}, χ_1, and ψ_1 are scalars

$\psi_1 := \upsilon_{11}\chi_1 + u_{12}^T x_2 + \psi_1$

Continue with

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Trmvp_un_unb_var1( U, x, y )

  [ UTL, UTR, ...
    UBL, UBR ] = FLA_Part_2x2( U, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( UTL, 1 ) < size( U, 1 ) )

    [ U00,  u01,      U02,  ...
      u10t, upsilon11, u12t, ...
      U20,  u21,      U22 ] = FLA_Repart_2x2_to_3x3( UTL, UTR, ...
                                                     UBL, UBR, ...
                                                     1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    psi1 = laff_dots( upsilon11, chi1, psi1 );
    psi1 = laff_dots( u12t, x2, psi1 );

    %-------------------------------------------------------------%
    [ UTL, UTR, ...
      UBL, UBR ] = FLA_Cont_with_3x3_to_2x2( U00,  u01,      U02,  ...
                                             u10t, upsilon11, u12t, ...
                                             U20,  u21,      U22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Trmvp_un_unb_var1.m`. ☛ Click for test script `test_Trmvp_un_unb_var1.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{TRMVP\_UN\_UNB\_VAR2}(U, x, y)$

Partition

$$U \rightarrow \left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where U_{TL} is 0×0, x_T, y_T are 0×1

while $m(U_{TL}) < m(U)$ **do**

Repartition

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & U_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where υ_{11}, χ_1, and ψ_1 are scalars

$y_0 := \chi_1 u_{01} + y_0$
$\psi_1 := \chi_1 \upsilon_{11} + \psi_1$

Continue with

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Trmvp_un_unb_var2( U, x, y )

  [ UTL, UTR, ...
    UBL, UBR ] = FLA_Part_2x2( U, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( UTL, 1 ) < size( U, 1 ) )

    [ U00,  u01,        U02,  ...
      u10t, upsilon11,  u12t, ...
      U20,  u21,        U22 ] = FLA_Repart_2x2_to_3x3( UTL, UTR, ...
                                                       UBL, UBR, ...
                                                       1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    y0 = laff_axpy( chi1, u01, y0 );
    psi1 = laff_axpy( chi1, upsilon11, psi1 );

    %-------------------------------------------------------------%
    [ UTL, UTR, ...
      UBL, UBR ] = FLA_Cont_with_3x3_to_2x2( U00,  u01,        U02,  ...
                                             u10t, upsilon11,  u12t, ...
                                             U20,  u21,        U22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Trmvp_un_unb_var2.m`. ☛ Click for test script `test_Trmvp_un_unb_var2.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{TRMVP\_LN\_UNB\_VAR1}(L, x, y)$

Partition

$$L \rightarrow \left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where L_{TL} is 0×0, x_T, y_T are 0×1

while $m(L_{TL}) < m(L)$ **do**

Repartition

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} L_{00} & l_{01} & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where λ_{11}, χ_1, and ψ_1 are scalars

$\psi_1 := l_{10}^T x_0 + \lambda_{11}\chi_1 + \psi_1$

Continue with

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} L_{00} & 01 & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Trmvp_ln_unb_var1( L, x, y )

  [ LTL, LTR, ...
    LBL, LBR ] = FLA_Part_2x2( L, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( LTL, 1 ) < size( L, 1 ) )

    [ L00,  l01,      L02,  ...
      l10t, lambda11, l12t, ...
      L20,  l21,      L22 ] = FLA_Repart_2x2_to_3x3( LTL, LTR, ...
                                                     LBL, LBR, ...
                                                     1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    psi1 = laff_dots( l10t, x0, psi1 );
    psi1 = laff_dots( lambda11, chi1, psi1 );

    %-------------------------------------------------------------%

    [ LTL, LTR, ...
      LBL, LBR ] = FLA_Cont_with_3x3_to_2x2( L00,  l01,      L02,  ...
                                             l10t, lambda11, l12t, ...
                                             L20,  l21,      L22,  ...
                                             'FLA_TL' );

    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );

    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );

  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Trmvp_ln_unb_var1.m`. ☛ Click for test script `test_Trmvp_ln_unb_var1.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{TRMVP\_LN\_UNB\_VAR2}(L, x, y)$

Partition

$$L \rightarrow \left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where L_{TL} is 0×0, x_T, y_T are 0×1

while $m(L_{TL}) < m(L)$ **do**

Repartition

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} L_{00} & l_{01} & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where λ_{11}, χ_1, and ψ_1 are scalars

$\psi_1 := \lambda_{11}\chi_1 + \psi_1$
$y_2 := \chi_1 l_{21} + y_2$

Continue with

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} L_{00} & 01 & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Trmvp_ln_unb_var2( L, x, y )

  [ LTL, LTR, ...
    LBL, LBR ] = FLA_Part_2x2( L, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( LTL, 1 ) < size( L, 1 ) )

    [ L00,  l01,       L02,  ...
      l10t, lambda11, l12t, ...
      L20,  l21,       L22 ] = FLA_Repart_2x2_to_3x3( LTL, LTR, ...
                                                      LBL, LBR, ...
                                                      1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    psi1 = laff_axpy( chi1, lambda11, psi1 );
    y2   = laff_axpy( chi1, l21, y2 );

    %-------------------------------------------------------------%

    [ LTL, LTR, ...
      LBL, LBR ] = FLA_Cont_with_3x3_to_2x2( L00,  l01,       L02,  ...
                                             l10t, lambda11, l12t, ...
                                             L20,  l21,       L22, ...
                                             'FLA_TL' );

    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );

    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );

  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Trmvp_ln_unb_var2.m`. ☛ Click for test script `test_Trmvp_ln_unb_var2.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $x := \text{TRMV\_UN\_UNB\_VAR1}(U, x)$

Partition

$$U \rightarrow \left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right), \; x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right)$$

where U_{TL} is 0×0, x_T is 0×1

while $m(U_{TL}) < m(U)$ **do**

Repartition

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & U_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

where υ_{11} and χ_1 are scalars

$\chi_1 := \upsilon_{11}\chi_1$

$\chi_1 := u_{12}^T x_2 + \chi_1$

Continue with

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & A_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

endwhile

```
function [ x_out ] = Trmv_un_unb_var1( U, x )

  [ UTL, UTR, ...
    UBL, UBR ] = FLA_Part_2x2( U, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );

  while ( size( UTL, 1 ) < size( U, 1 ) )

    [ U00,  u01,        U02,  ...
      u10t, upsilon11,  u12t, ...
      U20,  u21,        U22 ] = FLA_Repart_2x2_to_3x3( UTL, UTR, ...
                                                       UBL, UBR, ...
                                                       1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    chi1 = laff_dot( upsilon11, chi1 );
    chi1 = laff_dots( u12t, x2, chi1 );

    %-------------------------------------------------------------%
    [ UTL, UTR, ...
      UBL, UBR ] = FLA_Cont_with_3x3_to_2x2( U00,  u01,        U02,  ...
                                             u10t, upsilon11,  u12t, ...
                                             U20,  u21,        U22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
  end

  x_out = [ xT
            xB ];

return
```

☛ Click to view .m file `Trmv_un_unb_var1.m`. ☛ Click for test script `test_Trmv_un_unb_var1.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $x := \text{TRMV\_UN\_UNB\_VAR2}(U, x)$

Partition

$$U \rightarrow \left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right), \; x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right)$$

where U_{TL} is 0×0, x_T is 0×1

while $m(U_{TL}) < m(U)$ **do**

Repartition

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & U_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

where υ_{11} and χ_1 are scalars

$x_0 := \chi_1 u_{01} + x_0$

$\chi_1 := \chi_1 \upsilon_{11}$

Continue with

$$\left(\begin{array}{c|c} U_{TL} & U_{TR} \\ \hline U_{BL} & U_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} U_{00} & u_{01} & U_{02} \\ \hline u_{10}^T & \upsilon_{11} & u_{12}^T \\ \hline U_{20} & u_{21} & A_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

endwhile

```
function [ x_out ] = Trmv_un_unb_var2( U, x )

  [ UTL, UTR, ...
    UBL, UBR ] = FLA_Part_2x2( U, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );

  while ( size( UTL, 1 ) < size( U, 1 ) )

    [ U00,  u01,        U02,  ...
      u10t, upsilon11,  u12t, ...
      U20,  u21,        U22 ] = FLA_Repart_2x2_to_3x3( UTL, UTR, ...
                                                       UBL, UBR, ...
                                                       1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    x0 = laff_axpy( chi1, u01, x0 );
    chi1 = laff_dot( upsilon11, chi1 );

    %-------------------------------------------------------------%
    [ UTL, UTR, ...
      UBL, UBR ] = FLA_Cont_with_3x3_to_2x2( U00,  u01,        U02,  ...
                                             u10t, upsilon11,  u12t, ...
                                             U20,  u21,        U22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
  end

  x_out = [ xT
            xB ];

return
```

☛ Click to view .m file `Trmv_un_unb_var2.m`. ☛ Click for test script `test_Trmv_un_unb_var2.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $[x] := \text{TRMV\_LN\_UNB\_VAR1}(L, x)$

Partition

$$L \rightarrow \left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right), \; x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right)$$

where L_{BR} is 0×0, x_B has 0 rows

while $m(L_{BR}) < m(L)$ **do**

Repartition

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} L_{00} & l_{01} & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

where λ_{11} is 1×1, χ_1 has 1 row

$\chi_1 := \lambda_{11}\chi_1$

$\chi_1 := l_{10}^T x_0 + \chi_1$

Continue with

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} L_{00} & l_{01} & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

endwhile

```
function [ x_out ] = Trmv_ln_unb_var1( L, x )

  [ LTL, LTR, ...
    LBL, LBR ] = FLA_Part_2x2( L, ...
                               0, 0, 'FLA_BR' );

  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_BOTTOM' );

  while ( size( LBR, 1 ) < size( L, 1 ) )

    [ L00,  l01,     L02,  ...
      l10t, lambda11, l12t, ...
      L20,  l21,     L22 ] = FLA_Repart_2x2_to_3x3( LTL, LTR, ...
                                                    LBL, LBR, ...
                                                    1, 1, 'FLA_TL' );

    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_TOP' );

    %------------------------------------------------------------%

    chi1 = lambda11 * chi1;
    chi1 = l10t * x0 + chi1;

    %------------------------------------------------------------%

    [ LTL, LTR, ...
      LBL, LBR ] = FLA_Cont_with_3x3_to_2x2( L00,  l01,     L02,  ...
                                             l10t, lambda11, l12t, ...
                                             L20,  l21,     L22,  ...
                                             'FLA_BR' );

    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_BOTTOM' );

  end

  x_out = [ xT
            xB ];

return
```

☛ Click to view .m file `Trmv_ln_unb_var1.m`. ☛ Click for test script `test_Trmv_ln_unb_var1.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $[x] := \text{TRMV\_LN\_UNB\_VAR2}(L, x)$

Partition

$$L \rightarrow \left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right), \; x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right)$$

where L_{BR} is 0×0, x_B has 0 rows

while $m(L_{BR}) < m(L)$ **do**

Repartition

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} L_{00} & l_{01} & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

where λ_{11} is 1×1, χ_1 has 1 row

$x_2 := \chi_1 l_{21} + x_2$

$\chi_1 := \chi_1 \lambda_{11}$

Continue with

$$\left(\begin{array}{c|c} L_{TL} & L_{TR} \\ \hline L_{BL} & L_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} L_{00} & l_{01} & L_{02} \\ \hline l_{10}^T & \lambda_{11} & l_{12}^T \\ \hline L_{20} & l_{21} & L_{22} \end{array}\right), \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right)$$

endwhile

```
function [ x_out ] = Trmv_ln_unb_var2( L, x )

  [ LTL, LTR, ...
    LBL, LBR ] = FLA_Part_2x2( L, ...
                               0, 0, 'FLA_BR' );

  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_BOTTOM' );

  while ( size( LBR, 1 ) < size( L, 1 ) )

    [ L00,  l01,     L02,  ...
      l10t, lambda11, l12t, ...
      L20,  l21,     L22 ] = FLA_Repart_2x2_to_3x3( LTL, LTR, ...
                                                    LBL, LBR, ...
                                                    1, 1, 'FLA_TL' );

    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_TOP' );

    %------------------------------------------------------------%

    x2 = chi1 * l21 + x2;
    chi1 = lambda11 * chi1;

    %------------------------------------------------------------%

    [ LTL, LTR, ...
      LBL, LBR ] = FLA_Cont_with_3x3_to_2x2( L00,  l01,     L02,  ...
                                             l10t, lambda11, l12t, ...
                                             L20,  l21,     L22,  ...
                                             'FLA_BR' );

    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_BOTTOM' );

  end

  x_out = [ xT
            xB ];

return
```

☛ Click to view .m file `Trmv_ln_unb_var2.m`. ☛ Click for test script `test_Trmv_ln_unb_var2.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{SYMV\_U\_UNB\_VAR1}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where A_{TL} is 0×0, x_T, y_T are 0×1

while $m(A_{TL}) < m(A)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where α_{11}, χ_1, and ψ_1 are scalars

$$\psi_1 := a_{01}^T x_0 + \alpha_{11}\chi_1 + a_{12}^T x_2 + \psi_1$$

Continue with

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Symv_u_unb_var1( A, x, y )

  [ ATL, ATR, ...
    ABL, ABR ] = FLA_Part_2x2( A, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( ATL, 1 ) < size( A, 1 ) )

    [ A00,  a01,     A02,  ...
      a10t, alpha11, a12t, ...
      A20,  a21,     A22 ] = FLA_Repart_2x2_to_3x3( ATL, ATR, ...
                                                    ABL, ABR, ...
                                                    1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %------------------------------------------------------------%

    psi1 = laff_dots( a01, x0, psi1 );
    psi1 = laff_dots( alpha11, chi1, psi1 );
    psi1 = laff_dots( a12t, x2, psi1 );

    %------------------------------------------------------------%

    [ ATL, ATR, ...
      ABL, ABR ] = FLA_Cont_with_3x3_to_2x2( A00,  a01,     A02,  ...
                                             a10t, alpha11, a12t, ...
                                             A20,  a21,     A22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Symv_u_unb_var1.m`. ☛ Click for test script `test_Symv_u_unb_var1.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{SYMV\_U\_UNB\_VAR2}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where A_{TL} is 0×0, x_T, y_T are 0×1

while $m(A_{TL}) < m(A)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where α_{11}, χ_1, and ψ_1 are scalars

$y_0 := \chi_1 a_{01} + y_0$
$\psi_1 := \alpha_{11}\chi_1 + \psi_1$
$y_2 := \chi_1 (a_{12}^T)^T + y_2$

Continue with

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Symv_u_unb_var2( A, x, y )

  [ ATL, ATR, ...
    ABL, ABR ] = FLA_Part_2x2( A, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( ATL, 1 ) < size( A, 1 ) )

    [ A00,  a01,     A02,  ...
      a10t, alpha11, a12t, ...
      A20,  a21,     A22 ] = FLA_Repart_2x2_to_3x3( ATL, ATR, ...
                                                    ABL, ABR, ...
                                                    1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    y0 = laff_axpy( chi1, a01, y0 );
    psi1 = laff_axpy( chi1, alpha11, psi1 );
    y2 = laff_axpy( chi1, a12t, y2 );

    %-------------------------------------------------------------%

    [ ATL, ATR, ...
      ABL, ABR ] = FLA_Cont_with_3x3_to_2x2( A00,  a01,     A02,  ...
                                             a10t, alpha11, a12t, ...
                                             A20,  a21,     A22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Symv_u_unb_var2.m`. ☛ Click for test script `test_Symv_u_unb_var2.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{SYMV\_L\_UNB\_VAR1}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where A_{TL} is 0×0, x_T, y_T are 0×1

while $m(A_{TL}) < m(A)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where α_{11}, χ_1, and ψ_1 are scalars

$$\psi_1 := a_{10}^T x_0 + \alpha_{11}\chi_1 + a_{21}^T x_2 + \psi_1$$

Continue with

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Symv_l_unb_var1( A, x, y )

  [ ATL, ATR, ...
    ABL, ABR ] = FLA_Part_2x2( A, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( ATL, 1 ) < size( A, 1 ) )

    [ A00,  a01,     A02,  ...
      a10t, alpha11, a12t, ...
      A20,  a21,     A22 ] = FLA_Repart_2x2_to_3x3( ATL, ATR, ...
                                                    ABL, ABR, ...
                                                    1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %------------------------------------------------------------%

    psi1 = laff_dots( a10t, x0, psi1 );
    psi1 = laff_dots( alpha11, chi1, psi1 );
    psi1 = laff_dots( a21, x2, psi1 );

    %------------------------------------------------------------%

    [ ATL, ATR, ...
      ABL, ABR ] = FLA_Cont_with_3x3_to_2x2( A00,  a01,     A02,  ...
                                             a10t, alpha11, a12t, ...
                                             A20,  a21,     A22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Symv_l_unb_var1.m`. ☛ Click for test script `test_Symv_l_unb_var1.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{SYMV\_L\_UNB\_VAR2}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where A_{TL} is 0×0, x_T, y_T are 0×1

while $m(A_{TL}) < m(A)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where α_{11}, χ_1, and ψ_1 are scalars

$y_0 := \chi_1 (a_{10}^T)^T + y_0$
$\psi_1 := \alpha_{11}\chi_1 + \psi_1$
$y_2 := \chi_1 a_{21} + y_2$

Continue with

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Symv_l_unb_var2( A, x, y )

  [ ATL, ATR, ...
    ABL, ABR ] = FLA_Part_2x2( A, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( ATL, 1 ) < size( A, 1 ) )

    [ A00,  a01,     A02,  ...
      a10t, alpha11, a12t, ...
      A20,  a21,     A22 ] = FLA_Repart_2x2_to_3x3( ATL, ATR, ...
                                                    ABL, ABR, ...
                                                    1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %-------------------------------------------------------------%

    y0 = laff_axpy( chi1, a10t, y0 );
    psi1 = laff_axpy( chi1, alpha11, psi1 );
    y2 = laff_axpy( chi1, a21, y2 );

    %-------------------------------------------------------------%

    [ ATL, ATR, ...
      ABL, ABR ] = FLA_Cont_with_3x3_to_2x2( A00,  a01,     A02,  ...
                                             a10t, alpha11, a12t, ...
                                             A20,  a21,     A22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Symv_l_unb_var2.m`. ☛ Click for test script `test_Symv_l_unb_var2.m`. Then copy and paste it into PictureFlame to watch it in action.

Algorithm: $y := \text{SYMV\_U\_UNB\_VAR3}(A, x, y)$

Partition

$$A \rightarrow \left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right),$$
$$x \rightarrow \left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right), \; y \rightarrow \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right)$$

where A_{TL} is 0×0, x_T, y_T are 0×1

while $m(A_{TL}) < m(A)$ **do**

Repartition

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \rightarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \rightarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \rightarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

where α_{11}, χ_1, and ψ_1 are scalars

$y_0 := \chi_1 a_{01} + y_0$
$\psi_1 := \alpha_{11}\chi_1 + \psi_1$
$\psi 1 := a_{01}^T x_0 + \psi_1$

Continue with

$$\left(\begin{array}{c|c} A_{TL} & A_{TR} \\ \hline A_{BL} & A_{BR} \end{array}\right) \leftarrow \left(\begin{array}{c|c|c} A_{00} & a_{01} & A_{02} \\ \hline a_{10}^T & \alpha_{11} & a_{12}^T \\ \hline A_{20} & a_{21} & A_{22} \end{array}\right),$$
$$\left(\begin{array}{c} x_T \\ \hline x_B \end{array}\right) \leftarrow \left(\begin{array}{c} x_0 \\ \hline \chi_1 \\ \hline x_2 \end{array}\right), \; \left(\begin{array}{c} y_T \\ \hline y_B \end{array}\right) \leftarrow \left(\begin{array}{c} y_0 \\ \hline \psi_1 \\ \hline y_2 \end{array}\right)$$

endwhile

```
function [ y_out ] = Symv_u_unb_var3( A, x, y )

  [ ATL, ATR, ...
    ABL, ABR ] = FLA_Part_2x2( A, ...
                               0, 0, 'FLA_TL' );
  [ xT, ...
    xB ] = FLA_Part_2x1( x, ...
                         0, 'FLA_TOP' );
  [ yT, ...
    yB ] = FLA_Part_2x1( y, ...
                         0, 'FLA_TOP' );

  while ( size( ATL, 1 ) < size( A, 1 ) )

    [ A00,  a01,     A02,  ...
      a10t, alpha11, a12t, ...
      A20,  a21,     A22 ] = FLA_Repart_2x2_to_3x3( ATL, ATR, ...
                                                    ABL, ABR, ...
                                                    1, 1, 'FLA_BR' );
    [ x0, ...
      chi1, ...
      x2 ] = FLA_Repart_2x1_to_3x1( xT, ...
                                    xB, ...
                                    1, 'FLA_BOTTOM' );
    [ y0, ...
      psi1, ...
      y2 ] = FLA_Repart_2x1_to_3x1( yT, ...
                                    yB, ...
                                    1, 'FLA_BOTTOM' );
    %------------------------------------------------------------%

    y0 = laff_axpy( chi1, a01, y0 );
    psi1 = laff_axpy( chi1, alpha11, psi1 );
    psi1 = laff_dots( a01, x0, psi1 );

    %------------------------------------------------------------%

    [ ATL, ATR, ...
      ABL, ABR ] = FLA_Cont_with_3x3_to_2x2( A00,  a01,     A02,  ...
                                             a10t, alpha11, a12t, ...
                                             A20,  a21,     A22,  ...
                                             'FLA_TL' );
    [ xT, ...
      xB ] = FLA_Cont_with_3x1_to_2x1( x0, ...
                                       chi1, ...
                                       x2, ...
                                       'FLA_TOP' );
    [ yT, ...
      yB ] = FLA_Cont_with_3x1_to_2x1( y0, ...
                                       psi1, ...
                                       y2, ...
                                       'FLA_TOP' );
  end

  y_out = [ yT
            yB ];

return
```

☛ Click to view .m file `Symv_u_unb_var3.m`. ☛ Click for test script `test_Symv_u_unb_var3.m`. Then copy and paste it into PictureFlame to watch it in action.