

# *First-edition Book Errata, Version 1.3*

## *Preface*

### *Page xxv*

The statement

*Video\_Clips\TWS\Documents\Readme.PDF*

should read as follows:

*Part\_2\Video\_Clips\_TWS\Documents\Readme.PDF*

### *Page xxv*

The statement

*Video\_Clips\TWS\Flights*

should read as follows:

*Video\_Clips\_TWS\Flights*

## *Chapter 1*

### *Page 2*

The URL

*<http://goo.gl/DD82m>*

should read as follows:

*<http://tinyurl.com/ndw59la>*

***Page 3***

At the bottom of the page the statement

*Video\_Clips\TWS\Documents\Readme.PDF*

should read as follows:

*Part\_2\Video\_Clips\_TWS\Documents\Readme.PDF*

***Page 3***

At the bottom of the page the statement

*Video\_Clips\TWS\Flights*

should read as follows:

*Video\_Clips\_TWS\Flights*

***Page 9***

The statement

the throughput of the next wave of computers similar to dwarf

should read as follows:

the throughput of the next wave of computers similarly to dwarf

***Page 18***

The item

$X^*_{t_{n+1}, t_n}$

should read as follows:

$X^*_{t_{n+1}, t_n}$

***Page 39***

Footnote 13 should read as follows:

See References 106 – 110 and 157.

***Page 40***

The statement

with a (*1-Hz*) data rate

should read as follows:

with a *1-Hz* data rate

***Page 40***

The statement

In the down-loadable material there is a folder called ***Video\_Clips***, in which you will find two sub-folders:

should read as follows:

In the down-loadable material there are two folders called ***Part\_2*** and ***Part\_3*** in which you will find sub-folders relating to ***Doppler*** and ***TWS***:

***Page 41***

The statement

Please include the words ‘Tracking Filter’ in the title of your email.

should read as follows:

Please include the words *Tracking Filter Engineering* in the title of your email.

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## Chapter 2

### Page 60

In equation (2.2.1) each occurrence of the constant  $c$  should be replaced by  $-c$

In the notes below equation (2.2.1) the statement  $c = -\rho_0\alpha/2m$  should be replaced by  $c = \rho_0\alpha/2m$

### Page 71

The final three lines currently reads as follows:

However,

$$\exp(tA)\exp(tB) = \exp(t(A+B)) \quad (2.4.5)$$

if and only if  $A$  and  $B$  commute. ■■

Those lines should read as follows:

Moreover if  $A$  and  $B$  commute then

$$\exp(tA)\exp(tB) = \exp(t(A+B)) = \exp(tB)\exp(tA) \quad (2.4.5)$$

■■

### Page 83

Equation (2.6.16) currently reads as follows:

$$D \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \end{pmatrix} = \begin{pmatrix} 0 & I \\ 0 & 2k\dot{x}(t) \end{pmatrix}_{\mathbf{x}(t)} \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \end{pmatrix} \quad (2.6.16)$$

The four  $\delta$ 's should not be bold, and so the equation should read as follows:

$$D \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \end{pmatrix} = \begin{pmatrix} 0 & I \\ 0 & 2k\dot{x}(t) \end{pmatrix}_{\mathbf{x}(t)} \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \end{pmatrix} \quad (2.6.16)$$

**Page 87**

The statement

This DE is nonlinear. Deriving its sensitivity matrix  $A(\bar{\mathbf{X}}(t_n))$  using (2.6.13) we obtain

should read as follows:

This DE is nonlinear. Deriving its sensitivity matrix  $A(\bar{\mathbf{X}}(t_n))$  using (2.6.13) we obtain (see Problem 3.10)

**Page 87**

Equation (2.6.37) currently reads as follows:

$$D \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \\ \delta \omega \end{pmatrix} = A(\mathbf{X}(t)) \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \\ \delta \omega \end{pmatrix} \quad (2.6.37)$$

The six  $\delta$ 's should not be bold, and so the equation should read as follows:

$$D \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \\ \delta \omega \end{pmatrix} = A(\mathbf{X}(t)) \begin{pmatrix} \delta x(t) \\ \delta \dot{x}(t) \\ \delta \omega \end{pmatrix} \quad (2.6.37)$$

**Page 88**

The statement

in which  $\bar{x}_n$ ,  $\bar{\dot{x}}_n$  and  $\bar{\omega}$  are the values contained in the nominal trajectory

should read as follows:

in which  $\bar{x}_n$ ,  $\bar{\dot{x}}_n$  and  $\bar{\omega}$  are the values contained in the nominal trajectory's state vector at  $t_n$ , namely

**Page 88**

The statement

The parameters  $\bar{x}_n$ ,  $\bar{\dot{x}}_n$  and  $\bar{\omega}$  in (2.6.41) are the same three *fixed* values that specify the nominal trajectory in (2.6.40).

should read as follows:

The parameters  $\bar{x}_n$ ,  $\bar{\dot{x}}_n$  and  $\bar{\omega}$  in (2.6.42) are the same three *fixed* values that specify the nominal trajectory in (2.6.40).

**Page 90**

Equation (2.6.45) currently reads as follows:

$$\delta \mathbf{X}(t) \equiv (\delta x_1(t), \delta x_2(t), \delta x_3(t), \delta x_4(t), \delta x_5(t), \delta x_6(t))^T \quad (2.6.45)$$

The six  $\delta$ 's on the right-hand side of the equation should not be bold, and so the equation should read as follows:

$$\delta \mathbf{X}(t) \equiv (\delta x_1(t), \delta x_2(t), \delta x_3(t), \delta x_4(t), \delta x_5(t), \delta x_6(t))^T \quad (2.6.45)$$

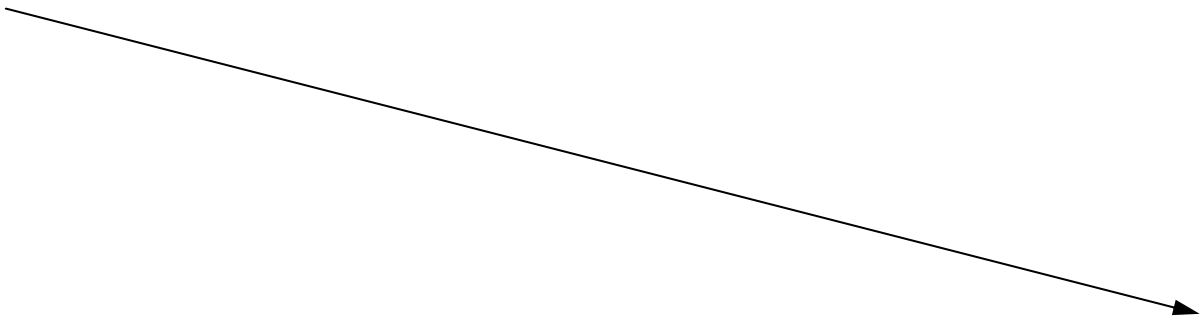
**Page 96**

Equation (A2.2.4) currently reads as follows:

$$[\mathbf{X}(t)]_i \equiv D^i x(t) \quad 0 \leq i \leq m \quad (\text{A2.2.4})$$

The  $i$  on the right should be a  $j$  and so the equation should read as follows:

$$[\mathbf{X}(t)]_j \equiv D^j x(t) \quad 0 \leq j \leq m \quad (\text{A2.2.4})$$



**Page 97**

Equation (A2.2.9) currently reads as follows:

$$\tau^i/i! D^i x((n+h)\tau) = \sum_{j=i}^m \binom{j}{i} h^{j-i} \tau^j/j! D^j x(n\tau), \quad 0 \leq i \leq m \quad (\text{A2.2.9})$$

The summation commences from  $j = i$ , and so the equation should read as follows:

$$\tau^i/i! D^i x((n+h)\tau) = \sum_{j=i}^m \binom{j}{i} h^{j-i} \tau^j/j! D^j x(n\tau) \quad 0 \leq i \leq m \quad (\text{A2.2.9})$$

**Page 97**

Equation (A2.2.10) currently reads as follows:

$$\mathbf{Z}_n \equiv (x, \tau\dot{x}, \tau^2/2! \ddot{x}, \dots, \tau^m/m! D^m x)_n^T \quad (\text{A2.2.10})$$

The 2 should not be bold, and so the equation should read as follows:

$$\mathbf{Z}_n \equiv (x, \tau\dot{x}, \tau^2/2! \ddot{x}, \dots, \tau^m/m! D^m x)_n^T \quad (\text{A2.2.10})$$

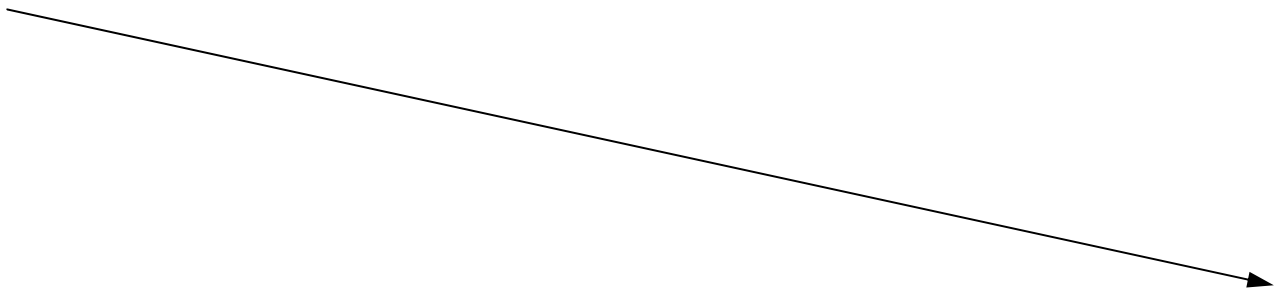
**Page 101**

Equation (A2.4.4) currently reads as follows:

$$D \begin{pmatrix} \delta x_1 \\ \delta x_2 \end{pmatrix} = \begin{pmatrix} f_1(x_1 + \delta x_1, x_2 + \delta x_2) \\ f_2(x_1 + \delta x_1, x_2 + \delta x_2) \end{pmatrix} - \begin{pmatrix} f_1(x_1, x_2) \\ f_2(x_1, x_2) \end{pmatrix} \quad (\text{A2.4.4})$$

The six  $\delta$ 's should not be bold, and so the equation should read as follows:

$$D \begin{pmatrix} \delta x_1 \\ \delta x_2 \end{pmatrix} = \begin{pmatrix} f_1(x_1 + \delta x_1, x_2 + \delta x_2) \\ f_2(x_1 + \delta x_1, x_2 + \delta x_2) \end{pmatrix} - \begin{pmatrix} f_1(x_1, x_2) \\ f_2(x_1, x_2) \end{pmatrix} \quad (\text{A2.4.4})$$



**Page 101**

Equation (A2.4.5) currently reads as follows:

$$D \begin{pmatrix} \delta x_1(t) \\ \delta x_2(t) \end{pmatrix} = \begin{pmatrix} D_{x_1} f_1(x_1(t), x_2(t)) & D_{x_2} f_1(x_1(t), x_2(t)) \\ D_{x_1} f_2(x_1(t), x_2(t)) & D_{x_2} f_2(x_1(t), x_2(t)) \end{pmatrix}_{\mathbf{x}(t)} \begin{pmatrix} \delta x_1(t) \\ \delta x_2(t) \end{pmatrix} \quad (\text{A2.4.5})$$

The four  $\delta$ 's should not be bold, and so the equation should read as follows:

$$D \begin{pmatrix} \delta x_1(t) \\ \delta x_2(t) \end{pmatrix} = \begin{pmatrix} D_{x_1} f_1(x_1(t), x_2(t)) & D_{x_2} f_1(x_1(t), x_2(t)) \\ D_{x_1} f_2(x_1(t), x_2(t)) & D_{x_2} f_2(x_1(t), x_2(t)) \end{pmatrix}_{\mathbf{x}(t)} \begin{pmatrix} \delta x_1(t) \\ \delta x_2(t) \end{pmatrix} \quad (\text{A2.4.5})$$

**Page 102**

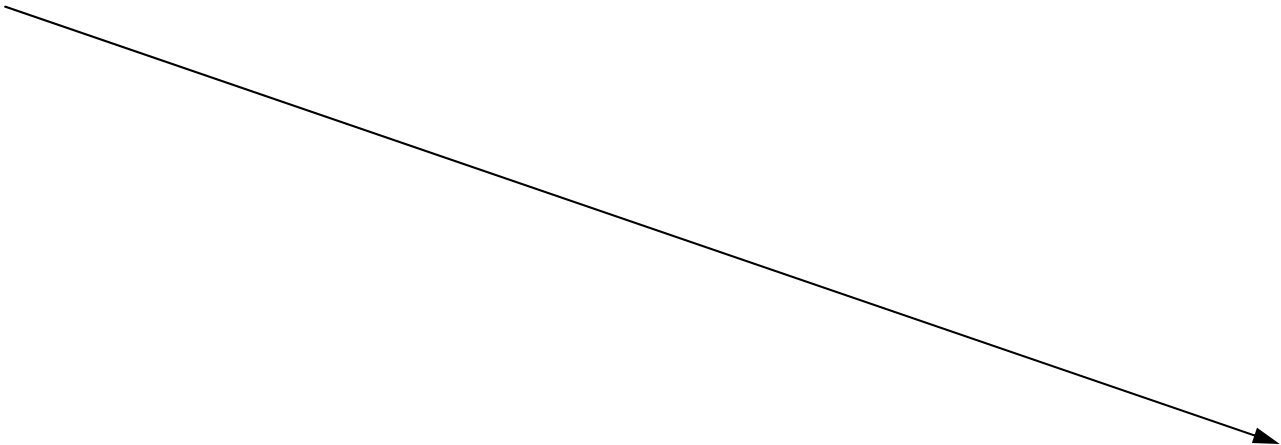
The statement

We refer you to Problems 2.24 and 2.25 where we ask you to apply the above.

should read as follows:

We refer you to Problems 2.18, 2.19, 2.20, 2.23, 2.24 where we ask you to apply the above.

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## *Chapter 3*

### *Page 116*

The first line currently reads as follows:

We now factor out  $X_n$  from the matrix on the right

The line should read as follows:

We now factor out  $X_n$  from the first vector on the right

### *Page 123*

The top line currently reads as follows:

All the equation that have

The top line should read as follows:

All the equations that have

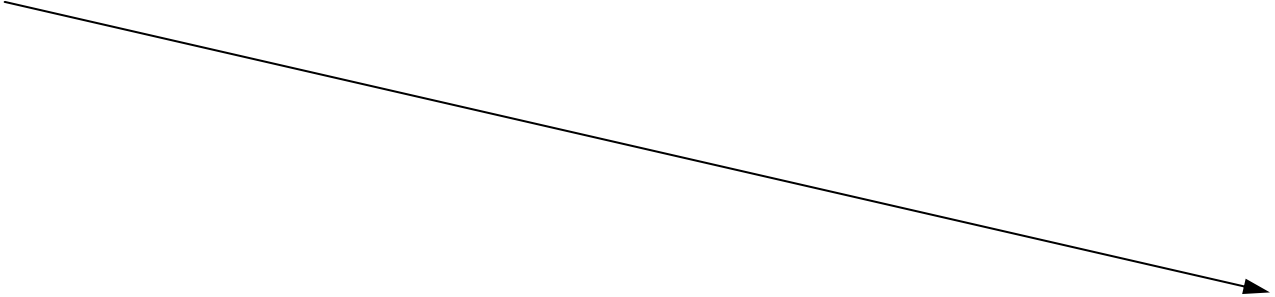
### *Page 123*

Equation (3.3.22) currently reads as follows:

$$[A(\mathbf{X}(t))]_{i,j} = \left. \frac{\partial f_i(x_1, \dots, x_m)}{\partial x_j} \right|_{\bar{\mathbf{X}}(t)} \quad 1 \leq i, j \leq m \quad (3.3.22)$$

There should be a bar over the  $\mathbf{X}$  on the far left, and so it should read as follows:

$$[A(\bar{\mathbf{X}}(t))]_{i,j} = \left. \frac{\partial f_i(x_1, \dots, x_m)}{\partial x_j} \right|_{\bar{\mathbf{X}}(t)} \quad 1 \leq i, j \leq m \quad (3.3.22)$$



**Page 124**

Equation (3.3.33) currently reads as follows:

$$\begin{pmatrix} \delta Y_n \\ \delta Y_{n-1} \\ \vdots \\ \delta Y_{n-L} \end{pmatrix} = \begin{pmatrix} M(\bar{X}_n) \delta X_n \\ M(\bar{X}_{n-1}) \Phi(t_{n-1}, t_n; \bar{X}) \delta \bar{X}_n \\ \vdots \\ M(\bar{X}_{n-L}) \Phi(t_{n-L}, t_n; \bar{X}) \delta \bar{X}_n \end{pmatrix} + \begin{pmatrix} N_n \\ N_{n-1} \\ \vdots \\ N_{n-L} \end{pmatrix} \quad (3.3.33)$$

There should not be bars over the  $\delta X_n$  in two places just to the left of the *plus* sign. The equation should therefore read as follows:

$$\begin{pmatrix} \delta Y_n \\ \delta Y_{n-1} \\ \vdots \\ \delta Y_{n-L} \end{pmatrix} = \begin{pmatrix} M(\bar{X}_n) \delta X_n \\ M(\bar{X}_{n-1}) \Phi(t_{n-1}, t_n; \bar{X}) \delta X_n \\ \vdots \\ M(\bar{X}_{n-L}) \Phi(t_{n-L}, t_n; \bar{X}) \delta X_n \end{pmatrix} + \begin{pmatrix} N_n \\ N_{n-1} \\ \vdots \\ N_{n-L} \end{pmatrix} \quad (3.3.33)$$

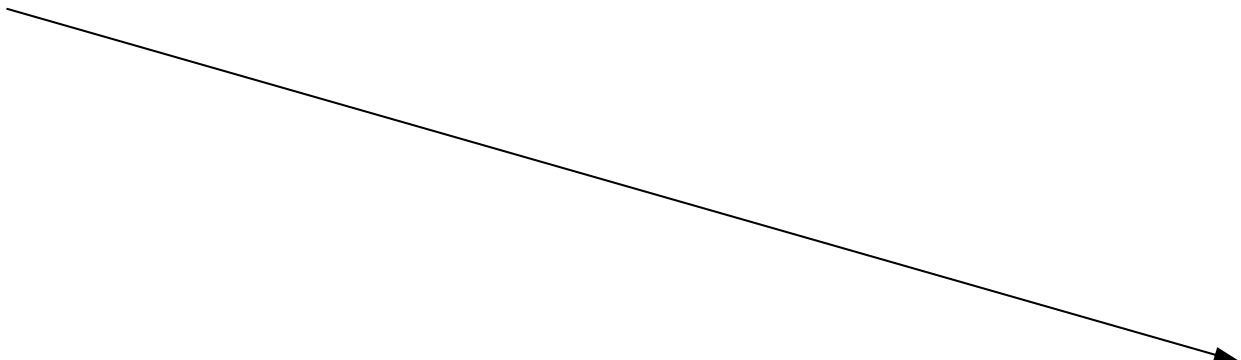
**Page 125**

Equation (3.3.36) currently reads as follows:

$$\delta Y_n = T(\bar{X}_n) \delta X_n + N_n \quad (3.3.36)$$

The final **N** should be sans-serif. Equation (3.3.36) should therefore read as follows:

$$\delta Y_n = T(\bar{X}_n) \delta X_n + \mathbf{N}_n \quad (3.3.36)$$



***Page 137***

In Figure A3.1.1: *ENU coordinates*

The vector from the origin to  $\mathbf{P}$  should be labelled  $\rho$ .

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***Chapter 4***

***Page 152***

The second last line on p. 152 currently reads as follows:

Let  $\mathbf{X}$  and  $\mathbf{Y}$  be two random vectors that have been partitioned as follows:

The line should read

Let  $\mathbf{X}$  and  $\mathbf{Y}$  be two random vectors of the same dimension that have been partitioned as follows:

***Page 156***

Just below equation (4.3.4) the text currently reads as follows:

and the only way in which the equality can be achieved for any of the  $a$ 's is if, for some nonzero vector  $\mathbf{c}$ ,

The text should read as follows

and the only way in which equality to 0 can be achieved for any of the  $a$ 's is if, for some nonzero vector  $\mathbf{c}$ ,

***Page 156***

Equation (4.3.7) currently reads as follows:

$$c_1v_1 + c_2v_2 + c_3v_3 = 0 \quad (4.3.1)$$

The equation should read as follows

$$c_1v_1 + c_2v_2 + c_3v_3 = 0 \quad \text{with probability } 1 \quad (4.3.2)$$

### ***Page 157***

The words "(see Appendix 2.1)" should read "(see Appendix 2.1 and Reference 203)"

### ***Page 161***

Equation (4.4.1) currently reads as follows:

$$\mathbf{R} = \mathbf{A}^T \mathbf{S} \mathbf{A} \quad (4.4.1)$$

The equation should read as follows:

$$\mathbf{R} = \mathbf{A} \mathbf{S} \mathbf{A}^T \quad (4.4.1)$$

### ***Page 165***

Theorem 4.5 currently reads as follows:

***Theorem 4.5:*** Let  $\mathbf{W}$  be an  $m \times k$  matrix where  $k > m$  (i.e.  $\mathbf{W}$  is wide) and let  $\mathbf{R}_Y$  be a positive-definite  $k \times k$  matrix. Then  $\mathbf{W} \mathbf{R}_Y \mathbf{W}^T$  is positive-definite if and only if  $\mathbf{W}$  has full row rank. ■■

The subscript  $Y$  in  $\mathbf{W} \mathbf{R}_Y \mathbf{W}^T$  should be sans-serif. The theorem should read as follows:

***Theorem 4.5:*** Let  $\mathbf{W}$  be an  $m \times k$  matrix where  $k > m$  (i.e.  $\mathbf{W}$  is wide) and let  $\mathbf{R}_Y$  be a positive-definite  $k \times k$  matrix. Then  $\mathbf{W} \mathbf{R}_Y \mathbf{W}^T$  is positive-definite if and only if  $\mathbf{W}$  has full row rank. ■■

### ***Page 170***

Equation (A4.1.5) and the line that follows it currently read as follows:

$$\begin{aligned} z &= r_{1,1}x^2 + 2r_{1,2}x(mx) + r_{2,2}(mx)^2 \\ &= (r_{1,1} + 2mr_{1,2} + m^2r_{2,2})x^2 = kx^2 \end{aligned} \quad (A4.1.5)$$

in which  $k$  is positive (because  $z > 0$ ).

The  $k$  should be  $b$ , and so (A4.1.5) and the line that follows should read as follows:

$$\begin{aligned} z &= r_{1,1}x^2 + 2r_{1,2}x(mx) + r_{2,2}(mx)^2 \\ &= (r_{1,1} + 2mr_{1,2} + m^2r_{2,2})x^2 = bx^2 \end{aligned} \quad (A4.1.5)$$

in which  $b$  is positive (because  $z > 0$ ).

**Page 171**

The statements

Using this in (A4.1.5) gives

$$z = Ax^2 = (k/(1+m^2))\|c\|^2 = k(m)\|c\|^2 \quad (\text{A4.1.8})$$

This means that there exists a positive constant  $k(m) \equiv A/(1+m^2)$  that is independent of  $\|c\|$

should read as follows:

Using this in (A4.1.5) gives

$$z = bx^2 = (b/(1+m^2))\|c\|^2 = k(m)\|c\|^2 \quad (\text{A4.1.8})$$

This means that there exists a positive constant  $k(m) \equiv b/(1+m^2)$  that is independent of  $\|c\|$

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**Chapter 6**

**Page 216**

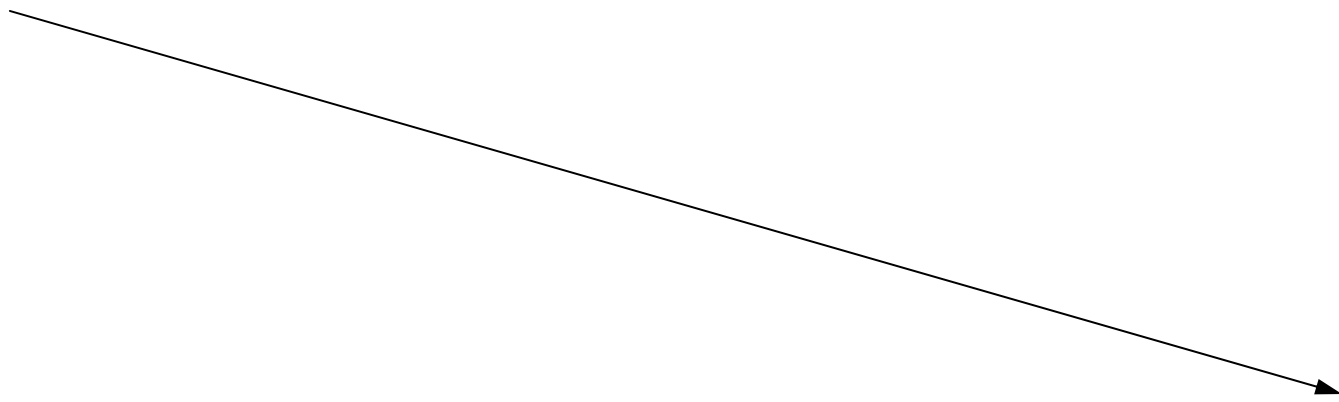
The statement

This is a contradiction, and so the only way in which (A6.2.3) can be true is if

The word *true*s should be *true*, and so the statement should read as follows:

This is a contradiction, and so the only way in which (A6.2.3) can be true is if

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## *Chapter 7*

### *Page 223*

The statement

*Note:* The square-root ratio matrix is of value because its diagonals contain the *accuracy ratios*.

should read as follows:

*Note:* If the matrices involved are covariance matrices then the square-root ratio matrix is of value because its diagonals contain the *accuracy ratios*.

### *Page 232*

The statement

(see Project 10.9)

should read as follows:

(see Project 10.6)

### *Page 235*

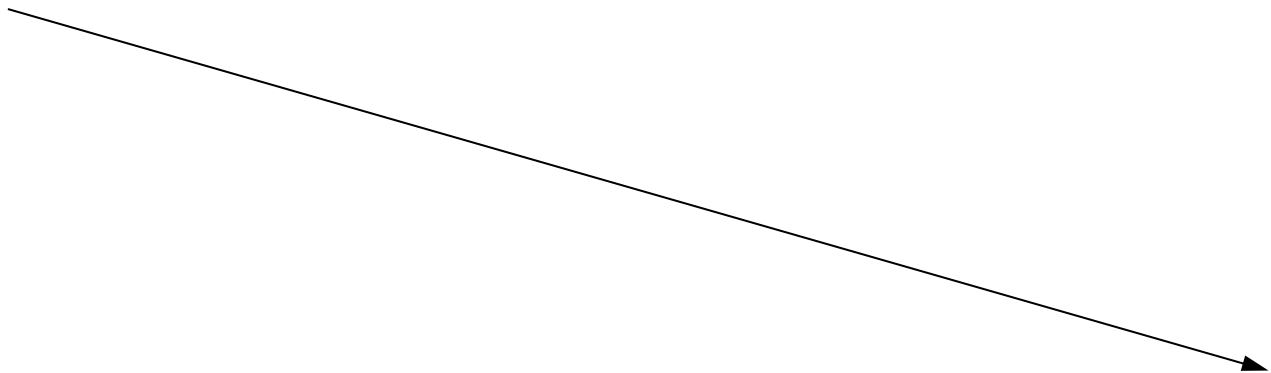
The statement

Let the state vector of the observed trajectory be the  $m$ -vector  $X$ .

should read as follows:

Let the true state vector of the observed trajectory be the  $m$ -vector  $X$ .

-----



## ***Chapter 8***

### ***Page 249***

In the final line on the page, the statement

Problems 9.3 and 9.4

should read

Problems 9.6 and 9.7.

### ***Page 253***

Equation (8.2.7) currently reads as follows:

$$\mathbf{N}_n^* \mathbf{N}_n^* = SSR = (v_n^{*2} + v_{n-1}^{*2} + v_{n-2}^{*2} + v_{n-3}^{*2} + v_{n-4}^*)_n \quad (8.2.1)$$

The star on the right are incorrectly placed. The equation should read

$$\mathbf{N}_n^{*T} \mathbf{N}_n^* = SSR = (v_n^{*2} + v_{n-1}^{*2} + v_{n-2}^{*2} + v_{n-3}^{*2} + v_{n-4}^{*2}) \quad (8.2.2)$$

### ***Page 257***

The statement

and also that Version 2 avoids two of the seven matrix multiplications

should read as follows:

and also that Version 2 avoids two of the six matrix multiplications

### ***Page 260***

The statement

From a practical point,  $S_{actual}$  in (8.3.5) is estimated by

should read as follows:

From a practical point,  $S_{actual}$  in (8.4.5) is estimated by

**Page 267**

The statement

We assume for simplicity that the observations  $y_1, y_2, \dots, y_n$  are uncorrelated and that the variances of their errors are respectively  $r_1, r_2, \dots, r_n$ . Then the covariance matrix of the long-vector  $\mathbf{Y}_n$  will be the diagonal matrix  $\mathbf{R}_{\mathbf{Y}_n} = \text{diag}(r_1, r_2, \dots, r_n)$ .

The  $y$ 's and  $r$ 's are incorrectly sequenced. The statement should read as follows:

We assume for simplicity that the observations  $y_n, y_{n-1}, \dots, y_1$  are uncorrelated and that the variances of their errors are respectively  $r_n, r_{n-1}, \dots, r_1$ . Then the covariance matrix of the long-vector  $\mathbf{Y}_n$  will be the diagonal matrix  $\mathbf{R}_{\mathbf{Y}_n} = \text{diag}(r_n, r_{n-1}, \dots, r_1)$ .

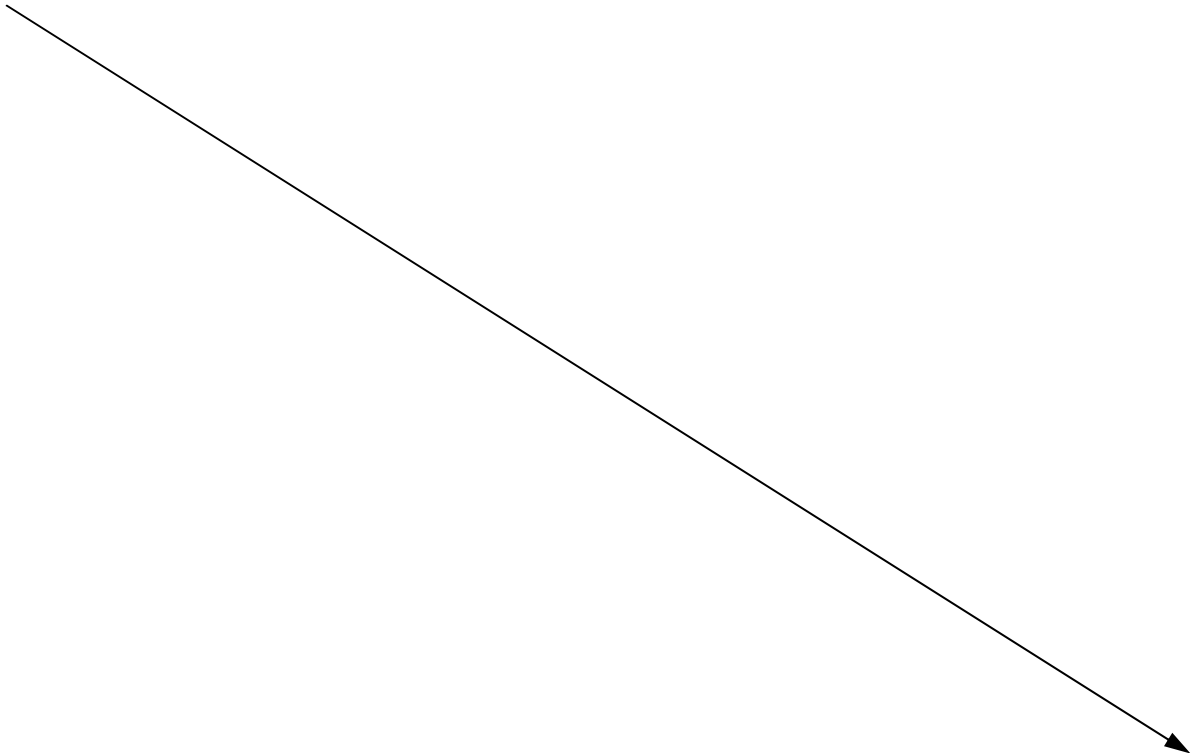
**Page 267**

Equation (8.5.7) currently reads as follows:

$$\mathbf{R}_{\mathbf{Y}_n}^{-1} = \text{diag}(1/r_1, 1/r_2, 1/r_3, 1/r_4, 1/r_5)_n^T \quad (8.5.7)$$

The  $r$ 's are incorrectly sequenced. The equation should read as follows:

$$\mathbf{R}_{\mathbf{Y}_n}^{-1} = \text{diag}(1/r_n, 1/r_{n-1}, 1/r_{n-2}, 1/r_{n-3}, 1/r_{n-4})^T \quad (8.5.7)$$



**Page 268**

Equation (8.5.11) currently reads as follows:

$$\begin{aligned} \mathbf{T}_2^T \mathbf{R}_{\mathbf{Y}_2}^{-1} \mathbf{T}_2 &= \begin{pmatrix} 1 & 1 \\ 0 & t_1 - t_2 \end{pmatrix} \begin{pmatrix} 1/r_1 & 0 \\ 0 & 1/r_2 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 1 & t_1 - t_2 \end{pmatrix} \\ &= \begin{pmatrix} 1/r_1 + 1/r_2 & (t_1 - t_2)/r_2 \\ (t_1 - t_2)/r_2 & (t_1 - t_2)^2/r_2 \end{pmatrix} \end{aligned} \quad (8.5.11)$$

The  $r$ 's are incorrectly sequenced. The equation should read as follows:

$$\begin{aligned} \mathbf{T}_2^T \mathbf{R}_{\mathbf{Y}_2}^{-1} \mathbf{T}_2 &= \begin{pmatrix} 1 & 1 \\ 0 & t_1 - t_2 \end{pmatrix} \begin{pmatrix} 1/r_2 & 0 \\ 0 & 1/r_1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 1 & t_1 - t_2 \end{pmatrix} \\ &= \begin{pmatrix} 1/r_2 + 1/r_1 & (t_1 - t_2)/r_1 \\ (t_1 - t_2)/r_1 & (t_1 - t_2)^2/r_1 \end{pmatrix} \end{aligned} \quad (8.5.11)$$

**Page 268**

The sentence

- ◊ At time  $t_2$  the filter is cycled, using as the inputs  $\mathbf{Y}_2 = (y_p, y_2)^T$  and the matrix  $\mathbf{R}_{\mathbf{Y}_2} = \text{diag}(r_1, r_2)$ . The outputs will be  $\mathbf{X}^*_{2,2}$  and  $\mathbf{S}^*_{2,2}$ .

The  $y$ 's and  $r$ 's are incorrectly sequenced. The sentence should read as follows:

- ◊ At time  $t_2$  the filter is cycled, using as the inputs  $\mathbf{Y}_2 = (y_2, y_1)^T$  and the matrix  $\mathbf{R}_{\mathbf{Y}_2} = \text{diag}(r_2, r_1)$ . The outputs will be  $\mathbf{X}^*_{2,2}$  and  $\mathbf{S}^*_{2,2}$ .

### ***Page 268***

The sentence

- ◇ At time  $t_3$  the filter is cycled, using as the inputs  $\mathbf{Y}_3 = (y_1, y_2, y_3)^T$  and the matrix  $\mathbf{R}_{\mathbf{Y}_3} = \text{diag}(r_1, r_2, r_3)$ . The outputs will be  $\mathbf{X}^*_{3,3}$  and  $\mathbf{S}^*_{3,3}$ .

The  $y$ 's and  $r$ 's are incorrectly sequenced. The sentence should read as follows:

- ◇ At time  $t_3$  the filter is cycled, using as the inputs  $\mathbf{Y}_3 = (y_3, y_2, y_1)^T$  and the matrix  $\mathbf{R}_{\mathbf{Y}_3} = \text{diag}(r_3, r_2, r_1)$ . The outputs will be  $\mathbf{X}^*_{3,3}$  and  $\mathbf{S}^*_{3,3}$ .

### ***Page 268***

The sentence

- ◇ At time  $t_4$  the filter is cycled using  $\mathbf{Y}_4 = (y_1, y_2, y_3, y_4)^T$  and  $\mathbf{R}_{\mathbf{Y}_4} = \text{diag}(r_1, r_2, r_3, r_4)$ . The outputs will be  $\mathbf{X}^*_{4,4}$  and  $\mathbf{S}^*_{4,4}$  and so on.

The  $y$ 's and  $r$ 's are incorrectly sequenced. The sentence should read as follows:

- ◇ At time  $t_4$  the filter is cycled using  $\mathbf{Y}_4 = (y_4, y_2, y_2, y_1)^T$  and  $\mathbf{R}_{\mathbf{Y}_4} = \text{diag}(r_4, r_3, r_2, r_1)$ . The outputs will be  $\mathbf{X}^*_{4,4}$  and  $\mathbf{S}^*_{4,4}$  and so on.

### ***Page 271***

The sentence

As noted earlier, Version 2 of the MVA requires five matrix multiplications whereas Version 1 requires seven, and so, all else being equal, we would use Version 2.

should read as follows:

As noted earlier, Version 2 of the MVA requires four matrix multiplications whereas Version 1 requires six, and so, all else being equal, we would use Version 2.

### ***Page 274***

The word *Notes* should read *Note*.

**Page 279**

The fourth group in equation (8.9.31) currently reads as follows:

$$\mathbf{R}^{-1} = \begin{pmatrix} \mathbf{R}_1^{-1} & | \\ \hline & \mathbf{R}_2^{-1} \end{pmatrix}$$

The  $\mathbf{R}$  on the left should be sans-serif. The equation should read as follows:

$$\mathbf{R}^{-1} = \begin{pmatrix} \mathbf{R}_1^{-1} & | \\ \hline & \mathbf{R}_2^{-1} \end{pmatrix}$$

**Page 282**

Equation (8.9.39) currently reads as follows:

$$\mathbf{X}^*_k = \mathbf{S}^*_{k-1}(\mathbf{S}^*_{k-1}\mathbf{X}^*_{k-1} + \mathbf{R}_k^{-1}\mathbf{Y}_k) \quad (8.9.39)$$

The first inverse sign is in the wrong place. The equation should read as follows:

$$\mathbf{X}^*_k = \mathbf{S}^*_k(\mathbf{S}^*_{k-1}\mathbf{X}^*_{k-1} + \mathbf{R}_k^{-1}\mathbf{Y}_k) \quad (8.9.39)$$

**Page 287**

Equation (A8.1.2) and the line following it currently read as follows:

$$\begin{aligned} D_{\mathbf{X}^*}((\mathbf{Y}_n - \mathbf{T}_n\mathbf{X}^*_{n,n})^T \mathbf{R}_{\mathbf{Y}_n}^{-1}(\mathbf{Y}_n - \mathbf{T}_n\mathbf{X}^*_{n,n})) \\ = -2\mathbf{T}_n^T \mathbf{R}_{\mathbf{Y}_n}^{-1}(\mathbf{Y}_n - \mathbf{T}_n\mathbf{X}^*_{n,n}) \end{aligned} \quad (A8.1.1)$$

Setting this result equal to  $\mathbf{0}$  and dropping the -2 we obtain

Equation (A8.1.2) and the line following it should read as follows:

$$\begin{aligned} D_{\mathbf{X}^*}((\mathbf{Y}_n - \mathbf{T}_n\mathbf{X}^*_{n,n})^T \mathbf{R}_{\mathbf{Y}_n}^{-1}(\mathbf{Y}_n - \mathbf{T}_n\mathbf{X}^*_{n,n})) \\ = -2(\mathbf{Y}_n - \mathbf{T}_n\mathbf{X}^*_{n,n})^T \mathbf{R}_{\mathbf{Y}_n}^{-1} \mathbf{T}_n \end{aligned} \quad (A8.1.2)$$

Setting the transpose of this result equal to  $\mathbf{0}$  and dropping the -2 we obtain

**Page 287**

The second last sentence currently reads as follows:

... is properly constructed then  $\mathbf{T}_n$  will read as follows:

The word *will* should be in italics. The sentence should read as follows:

... is properly constructed then  $\mathbf{T}_n$  *will* read as follows:

-----  
**Chapter 9**

**Page 314**

The statement

Proof of the lemma is given in Problem 9.9.

should read as follows:

Proof of the lemma is given in Problem 9.14.

**Page 320**

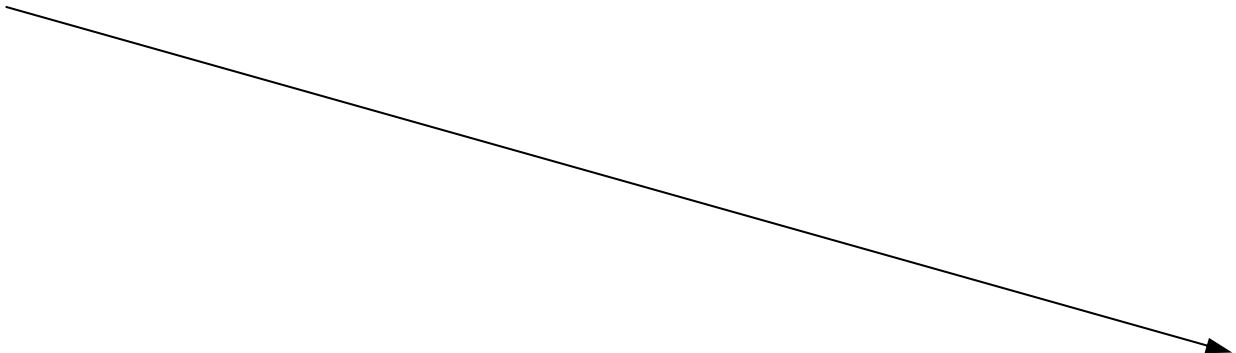
In Appendix 9.3, equation (A9.3.2) currently reads as follows:

$$L = (2\pi)^{-k/2} |\mathbf{R}|^{-1/2} \exp(-1/2(\mathbf{Y}-\mathbf{TX}^*)^T \mathbf{R}_Y^{-1}(\mathbf{Y}-\mathbf{TX}^*)) \quad (\text{A9.3.2})$$

The first  $\mathbf{R}$  should have a subscript. The equation should read as follows:

$$L = (2\pi)^{-k/2} |\mathbf{R}_Y|^{-1/2} \exp(-1/2(\mathbf{Y}-\mathbf{TX}^*)^T \mathbf{R}_Y^{-1}(\mathbf{Y}-\mathbf{TX}^*)) \quad (\text{A9.3.2})$$

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## ***Chapter 10***

### ***Page 339***

The statement

***Video\_Clips\TWS\Flights***

should read as follows:

***Part\_2\Video\_Clips\_TWS\Flights***

### ***Page 339***

The statement

***Video\_Clips\TWS\Documents\Readme***

should read as follows:

***Part\_2\Video\_Clips\_TWS\Documents\Readme***

### ***Page 344***

The statement

These are then transformed to Cartesian coordinates and fed to three filters – Kalman, Swerling and Gauss-Newton

should read as follows:

These are then transformed to Cartesian coordinates and, after prefiltering, are fed to three filters – Kalman, Swerling and Gauss-Newton

### ***Page 349***

The statement

the values  $X^*_{max}$ ,  $S^*_{max}$  and  $SSR^*_{max}$  have been placed in storage

The  $SSR$  should not have a star. The statement should read as follows:

the values  $X^*_{max}$ ,  $S^*_{max}$  and  $SSR_{max}$  have been placed in storage

### ***Page 351***

The statement

In (A10.1.5) we show the values for  $N_{X^*3}$ ,  $N_{X^*4}$  and  $N_{X^*5}$ .

should read as follows:

In (A10.1.4) we show the values for  $N_{X^*3}$ ,  $N_{X^*4}$  and  $N_{X^*5}$ .

---

## ***Chapter 11***

### ***Page 387***

The first paragraph currently reads as follows:

As an example, we see from Figure A11.16.3 that when  $N = 1600$ , on average the Gauss–Newton  $\hat{x}$ ,  $\hat{y}$  and  $\hat{z}$  estimates are *100* times more accurate than those of Kalman.

The figure number is incorrect. The paragraph should read as follows:

As an example, we see from Figure A11.4.3 that when  $N = 1600$ , on average the Gauss–Newton  $\hat{x}$ ,  $\hat{y}$  and  $\hat{z}$  estimates are *100* times more accurate than those of Kalman.

---

## ***Chapter 12***

### ***Page 417***

In Example 12.7 the three variables on the left of the equations currently read

$$\sigma(x_0^{*101, 100}), \sigma(x_1^{*101, 100}), \sigma(x_2^{*101, 100})$$

They should read

$$\sigma(x_0^{*1001, 1000}), \sigma(x_1^{*1001, 1000}), \sigma(x_2^{*1001, 1000})$$

**Page 420**

In Figure 12.21(b) the expression

$$20(1 - \theta)^7/\tau^2(1 + \theta)^7$$

The item  $\tau^2$  is incorrect. The expression should read as follows:

$$20(1 - \theta)^7/\tau^6(1 + \theta)^7$$

**Page 420**

In Figure 12.21(b) the expression

$$\frac{5(449\theta^6 + 2988\theta^5 + 10013\theta^4 + 21216\theta^3 + 28923\theta^2 + 25588\theta + 12199)(1 - \theta)^3}{72\tau^2(1 + \theta)^9}$$

There is a division line missing. The expression should be as follows:

$$\frac{5(449\theta^6 + 2988\theta^5 + 10013\theta^4 + 21216\theta^3 + 28923\theta^2 + 25588\theta + 12199)(1 - \theta)^3}{72\tau^2(1 + \theta)^9}$$

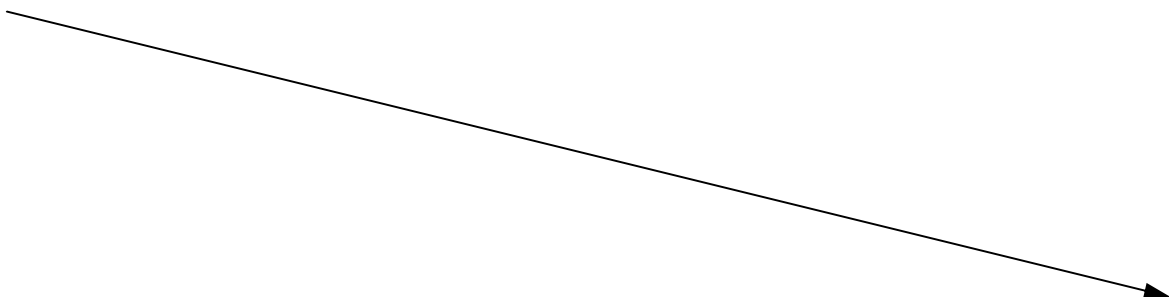
**Page 423**

Equation (12.2.56) now reads

$$\mathbf{VRF}(X^*_{n+1,n}) = \begin{pmatrix} 1.25(1-\theta) & 6(1-\theta)^2/\tau \\ 6(1-\theta)^2/\tau & 12(1-\theta)^3/\tau^2 \end{pmatrix} \quad (12.2.56)$$

The 6s and the 12 are incorrect. The equation should read as follows:

$$\mathbf{VRF}(X^*_{n+1,n}) = \begin{pmatrix} 1.25(1-\theta) & 0.5(1-\theta)^2/\tau \\ 0.5(1-\theta)^2/\tau & 0.25(1-\theta)^3/\tau^2 \end{pmatrix} \quad (12.2.56)$$



**Page 423**

Equation (12.2.57) now reads

$$VRF(X^*_{n+1,n}) = \begin{pmatrix} 2.0625(1-\theta) & 1.6875(1-\theta)^2/\tau & 0.5(1-\theta)^3/\tau^2 \\ 1.6875(1-\theta)^2/\tau & 1.75(1-\theta)^3/\tau^2 & 0.5625(1-\theta)^4/\tau^3 \\ 0.5(1-\theta)^3/\tau^2 & 0.5625(1-\theta)^4/\tau^3 & 1.1875(1-\theta)^5/\tau^4 \end{pmatrix} \quad (12.2.57)$$

The coefficient 1.1875 is incorrect. The equation should read as follows:

$$VRF(X^*_{n+1,n}) = \begin{pmatrix} 2.0625(1-\theta) & 1.6875(1-\theta)^2/\tau & 0.5(1-\theta)^3/\tau^2 \\ 1.6875(1-\theta)^2/\tau & 1.75(1-\theta)^3/\tau^2 & 0.5625(1-\theta)^4/\tau^3 \\ 0.5(1-\theta)^3/\tau^2 & 0.5625(1-\theta)^4/\tau^3 & 0.1875(1-\theta)^5/\tau^4 \end{pmatrix} \quad (12.2.57)$$

**Page 423**

The second equation in (12.2.58) now reads

$$\sigma_{(x|_{n+1}, n)} = 1.5 ((13\theta^2 + 50\theta + 49)(1 - \theta)^3 2\tau^2 (1 + \theta)^5)^{1/2} \approx 0.57 \text{ m/sec} \quad (12.2.58)$$

The division sign (slash) is missing before the 2. The equation should read as follows:

$$\sigma_{(x|_{n+1}, n)} = 1.5 ((13\theta^2 + 50\theta + 49)(1 - \theta)^3 / 2\tau^2 (1 + \theta)^5)^{1/2} \approx 0.57 \text{ m/sec} \quad (12.2.58)$$

**Page 427**

The sentence just below Figure 12.26 currently reads as follows:

Smoothing in Cartesian coordinate solves another problem as well.

The word *coordinate* is incorrect. The sentence should read as follows:

Smoothing in Cartesian coordinates solves another problem as well.

***Page 449***

The final line on the page currently reads as follows:

Repeating the calculation for the remaining degrees  $(0, 1, 3, 4)$ , we obtain Figure 12.10.

The figure number is incorrect. The line should read as follows:

Repeating the calculation for the remaining degrees  $(0, 1, 3, 4)$ , we obtain Figure 12.43.

***Page 455***

The statement

"... we are approximating the orbit by..."

should read as follows:

"... we are approximating the orbits by..."

***Page 458***

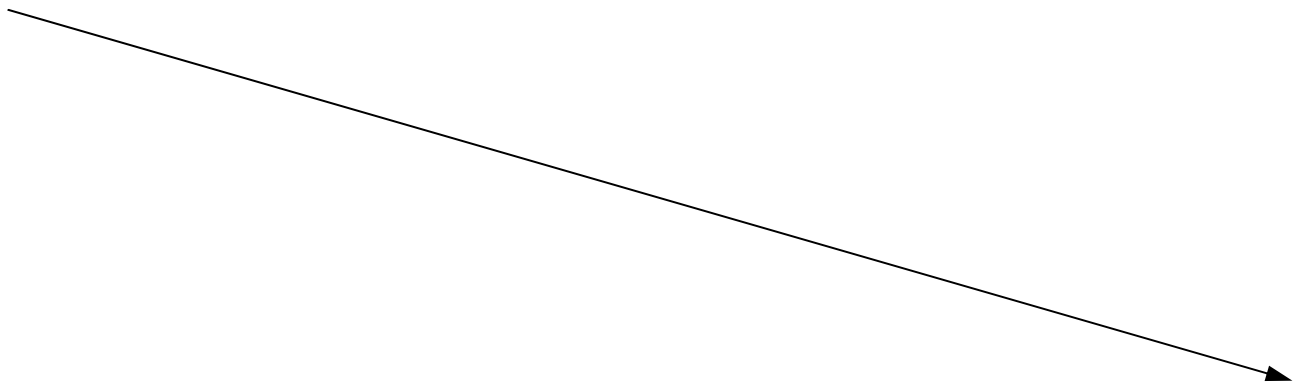
In the final paragraph, the statement

"... and there is a problem needs to be..."

should read as follows:

"... and there is a problem that needs to be..."

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## Chapter 13

### Page 474

Equation (13.1.9) currently reads as follows:

$$(c_j(n))^2 \equiv \sum_{s=0}^n (p_i(s, n))^2 \quad (13.1.9)$$

The term  $p_i$  on the right should be  $p_j$ . The equation should therefore read as follows:

$$(c_j(n))^2 \equiv \sum_{s=0}^n (p_j(s, n))^2 \quad (13.1.9)$$

### Page 490

Equation (13.2.29) currently reads as follows:

$$(\mathbf{C}(n))^2 = \begin{pmatrix} 1/c_0(n)^2 & 0 \\ 0 & 1/c_0(n)^2 \end{pmatrix} = \begin{pmatrix} 1/(n+1) & 0 \\ 0 & 3n/(n+2)(n+1) \end{pmatrix} \quad (13.2.29)$$

The second term in the first matrix should be  $1/c_1(n)^2$ . The equation should therefore read as follows:

$$(\mathbf{C}(n))^2 = \begin{pmatrix} 1/c_0(n)^2 & 0 \\ 0 & 1/c_1(n)^2 \end{pmatrix} = \begin{pmatrix} 1/(n+1) & 0 \\ 0 & 3n/(n+2)(n+1) \end{pmatrix} \quad (13.2.29)$$

### Page 491

The statement

The matrix  $\mathbf{D}(\tau)$  was defined in (11.2.1).

should read as follows:

The matrix  $\mathbf{D}(\tau)$  was defined in (12.2.11).

**Page 491**

The statement

See Project 12.2 in the supplementary material for comments regarding denormalization in the computer programs.

should read as follows:

See Projects 12.2 and 13.3 in the supplementary material for comments regarding denormalization in the computer programs.

**Page 492**

The statement

When  $m = 0$  or  $1$  it is possible to form these expansions by hand

The word *theses* is incorrect. The statement should read as follows:

When  $m = 0$  or  $1$  it is possible to form these expansions by hand

**Page 492**

The statement

where  $\Phi(l)$  is the transition matrix defined in (2.3.17)

should read as follows:

where  $\Phi(l)$  is the transition matrix defined in (2.3.14)

**Page 492**

Equation (13.2.39) currently reads as follows:

$$S^*(X_{n+1,n}^*) = \Phi(\tau) S^*(X_{n+1,n}^*) \Phi(\tau)^T \quad (13.2.39)$$

The subscript in  $X_{n+1,n}^*$  on the right is incorrect. The equation should read as follows:

$$S^*(X_{n+1,n}^*) = \Phi(\tau) S^*(X_{n,n}^*) \Phi(\tau)^T \quad (13.2.39)$$

**Page 501**

Equation (13.3.18) currently reads as follows:

$$e_n = \sum_{k=0}^{\infty} \left( y_{n-k} - \sum_{j=0}^m (\beta_j)_n \varphi_j(k, \theta) \right)^2 \theta^k \quad (13.3.18)$$

The equation should read as follows:

$$e_n = \sum_{k=0}^{\infty} \left( y_{n-k} - \sum_{j=0}^m \beta_{j,n} \varphi_j(k, \theta) \right)^2 \theta^k \quad (13.3.18)$$

**Page 501**

Equation (13.3.19) currently reads as follows:

$$\sum_{k=0}^{\infty} \left( y_{n-k} - \sum_{j=0}^m (\beta_j)_n \varphi_j(k, \theta) \right) \theta^k \varphi_i(k, \theta) = 0 \quad 0 \leq i \leq m \quad (13.3.19)$$

The equation should read as follows:

$$\sum_{k=0}^{\infty} \left( y_{n-k} - \sum_{j=0}^m \beta_{j,n} \varphi_j(k, \theta) \right) \theta^k \varphi_i(k, \theta) = 0 \quad 0 \leq i \leq m \quad (13.3.19)$$

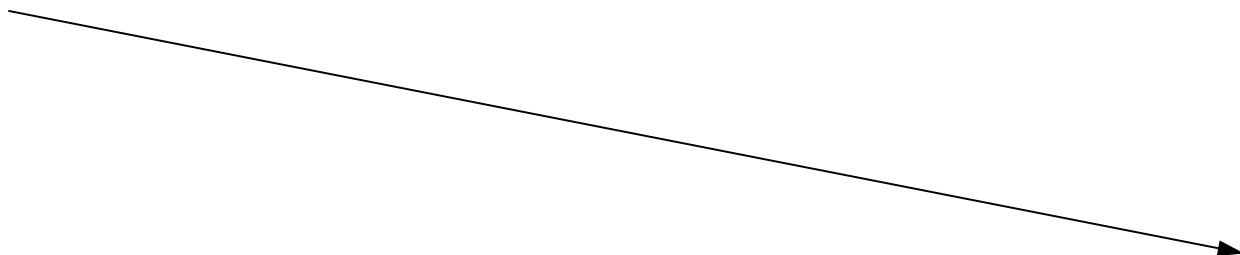
**Page 501**

Equation (13.3.20) currently reads as follows:

$$\sum_{j=0}^m (\beta_j)_n \sum_{k=0}^{\infty} \varphi_i(k, \theta) \varphi_j(k, \theta) \theta^k = \sum_{k=0}^{\infty} \varphi_i(k, \theta) \theta^k y_{n-k} \quad 0 \leq i \leq m \quad (13.3.20)$$

The equation should read as follows:

$$\sum_{j=0}^m \beta_{j,n} \sum_{k=0}^{\infty} \varphi_i(k, \theta) \varphi_j(k, \theta) \theta^k = \sum_{k=0}^{\infty} \varphi_i(k, \theta) \theta^k y_{n-k} \quad 0 \leq i \leq m \quad (13.3.20)$$



**Page 501**

Equation (13.3.21) currently reads as follows:

$$\sum_{j=0}^m (\beta_j)_n \delta_{i,j} = \sum_{k=0}^{\infty} \varphi_i(k, \theta) \theta^k y_{n-k} \quad 0 \leq i \leq m \quad (13.3.21)$$

The equation should read as follows:

$$\sum_{j=0}^m \beta_{j,n} \delta_{i,j} = \sum_{k=0}^{\infty} \varphi_i(k, \theta) \theta^k y_{n-k} \quad 0 \leq i \leq m \quad (13.3.21)$$

**Page 501**

Equation (13.3.22) currently reads as follows:

$$\beta_{i,n} = \sum_{k=0}^{\infty} \varphi_i(k, \theta) \theta^k y_{-k} \quad 0 \leq i \leq m \quad (13.3.22)$$

An  $n$  is missing in the subscript after the  $y$ . The equation should read as follows:

$$\beta_{i,n} = \sum_{k=0}^{\infty} \varphi_i(k, \theta) \theta^k y_{n-k} \quad 0 \leq i \leq m \quad (13.3.22)$$

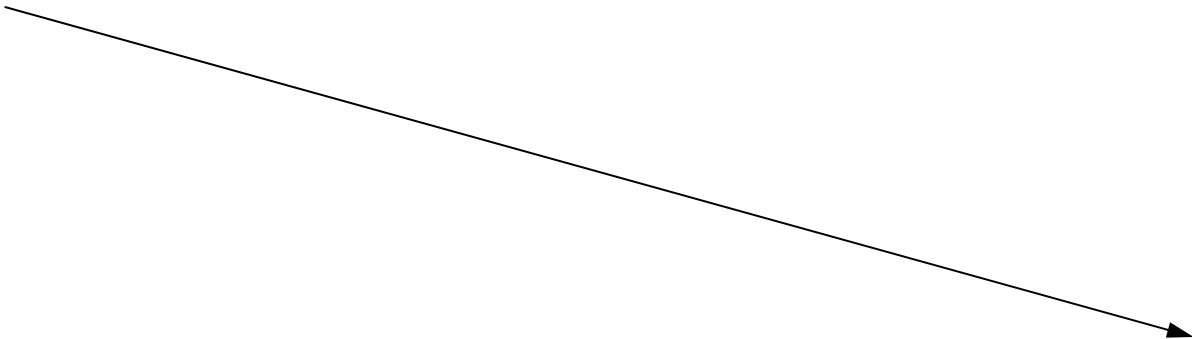
**Page 504**

Equation (13.3.38) currently reads as follows:

$$z_i^*_{n-s,n} = \sum_{j=0}^m (-1)^j / j! \left. \frac{d^j}{ds^j} \varphi_j(s, \theta) \right|_{s=-1} \left[ \sum_{k=0}^{\infty} \varphi_j(k, \theta) \theta^k y_{n-k} \right] \quad 0 \leq i \leq m \quad (13.3.38)$$

A factorial symbol is missing after  $/j$ . The equation should read as follows:

$$z_i^*_{n-s,n} = \sum_{j=0}^m (-1)^j / j! \left. \frac{d^j}{ds^j} \varphi_j(s, \theta) \right|_{s=-1} \left[ \sum_{k=0}^{\infty} \varphi_j(k, \theta) \theta^k y_{n-k} \right] \quad 0 \leq i \leq m \quad (13.3.38)$$



**Page 505**

Equation (13.3.40) currently reads as follows:

$$[\mathbf{L}(\theta)]_j \equiv \theta^j / c(j, \theta) \quad 0 \leq i, j \leq m \quad (13.3.40)$$

The term  $c(j, \theta)$  is squared, and so the equation should read as follows:

$$[\mathbf{L}(\theta)]_j \equiv \theta^j / (c(j, \theta))^2 \quad 0 \leq i, j \leq m \quad (13.3.40)$$

**Page 510**

The matrix element  $p_{1,4}$  currently reads as follows:

$$p_{1,4} = -20s/n + 90(2s-1)/n^{(2)} - 140(3s^2 - 6s+2)/n^{(3)} + 70(4s^3 - 18s^2 + 22s - 6)/n^{(4)}$$

The  $s$  appearing in  $-20s/n$  is incorrect. The expression should read as follows:

$$p_{1,4} = -20/n + 90(2s-1)/n^{(2)} - 140(3s^2 - 6s+2)/n^{(3)} + 70(4s^3 - 18s^2 + 22s - 6)/n^{(4)}$$

**Page 512**

The heading currently reads as follows:

$$3. \text{ The matrix } [\mathbf{P}(n,n)]_{i,j} = 1/i! \left. \frac{d^i}{ds^i} (p_j(s,n)) \right|_{s=n} \quad 0 \leq i, j \leq 4$$

The extra bracket before the  $p_j$  is incorrect. The heading should read as follows:

$$3. \text{ The matrix } [\mathbf{P}(n,n)]_{i,j} = 1/i! \left. \frac{d^i}{ds^i} p_j(s,n) \right|_{s=n} \quad 0 \leq i, j \leq 4$$

**Page 516**

In Appendix 13.5, in the first row of the matrix the second term currently reads as follows:

$$\theta^2(1 - bs)$$

The term should read as follows:

$$\theta(1 - bs)$$

### ***Page 516***

In Appendix 13.5, in the first row of the matrix the fourth term currently reads as follows:

$$-\theta^3(1 - 3bs + 3b^2(s^2-s)/2 - b^3(s^3-3s^2+2s)/6)$$

The minus sign before the  $\theta^3$  is incorrect. The term should read as follows:

$$\theta^3(1 - 3bs + 3b^2(s^2-s)/2 - b^3(s^3-3s^2+2s)/6)$$

### ***Page 527***

The References in the book currently end at *Reference 202*.

The following references should be added:

203: Cramér-Rao Bound

[http://en.wikipedia.org/wiki/Cram%C3%A9r%E2%80%93Rao\\_bound](http://en.wikipedia.org/wiki/Cram%C3%A9r%E2%80%93Rao_bound)

204: Cross Validated, <http://stats.stackexchange.com/questions/38382/why-doesnt-the-cramer-rao-lower-bound-apply>

205: The Discovery of Ceres, <http://www.keplersdiscovery.com/Asteroid.html>

206: Lecture 3, Some Linear Algebra,

<http://www.math.utah.edu/~davar/math6010/2011/SomeLinearAlgebra.pdf>

207: Projection Matrix, <http://mathworld.wolfram.com/ProjectionMatrix.html>

**Note:** We have reproduced all references obtained from the Internet as PDFs. They can be downloaded as a *ZIP* file from the supplementary material.