Errata and addenda for "Geometric Control of Mechanical Systems"

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This document records errors in the book "Geometric Control of Mechanical Systems" by **?**. These will be listed in order of page number and will be dated according to the order in which we discover them. Also included here will be style changes made to the text that are not necessarily errors.

Should you wish to make an error report, please contact the authors by visiting the webpage for the book:

`http://penelope.mast.queensu.ca/smcs/`

Errata and addenda

1. Cover (31/08/2004): Order of authors is incorrect.
2. Page 7, u13 (21/02/2004 from Alejandro Roa): There is an extra "also".
3. Page 11, d13 (22/03/2005 from Akihiro Sato): Change "is the that of [Crouch 1984]" to "is that of Crouch [1984]".
4. Page 21, d5 (28/03/2005 from John Mardlin): Change "$x = x$" to the slightly more interesting "$x = y$".
5. Page 21, d12 (27/01/2006): Change "$x \in S$" to $y \in S$".
6. Page 24, u14 (27/01/2006): Change "$v_1, v_1 \in \mathsf{V}$" to "$v_1, v_2 \in \mathsf{V}$".
7. Page 26, u7 (02/03/2007 from Pantelis Isaiah): Replace "This use of matrices is" with "This use of matrices in".
8. Page 41, u18 (27/01/2006): Change

$$L(\underbrace{\mathsf{V}^* \times \cdots \times \mathsf{V}^*}_{r \text{ copies}} \times \underbrace{\mathsf{V} \times \cdots \times \mathsf{V}}_{s \text{ copies}}; \mathbb{R})$$

   to

$$L(\underbrace{\mathsf{V}^*, \ldots, \mathsf{V}^*}_{r \text{ copies}}, \underbrace{\mathsf{V}, \ldots, \mathsf{V}}_{s \text{ copies}}; \mathbb{R}).$$

9. Page 46, u10 (28/02/2008): Replace "quadratic function" with "smooth quadratic function".
10. Page 57, d13 (03/07/2006): Make the replacement

$$\lim_{\boldsymbol{x} \to \mathbf{0}} \frac{o(\|\boldsymbol{x}\|^k_{\mathbb{R}^n})}{\|\boldsymbol{x}\|^k_{\mathbb{R}^n}} = 0 \quad \Longrightarrow \quad \lim_{\boldsymbol{x} \to \mathbf{0}} \frac{\|o(\|\boldsymbol{x}\|^k_{\mathbb{R}^n})\|_{\mathbb{R}^m}}{\|\boldsymbol{x}\|^k_{\mathbb{R}^n}} = 0.$$

11. Page 59, d14 (22/11/2004): "$o(\|\boldsymbol{v}\|^{r+1}_{\mathbb{R}^n})$" should be "$O(\|\boldsymbol{v}\|^{r+1}_{\mathbb{R}^n})$".

12. Page 74, d10 (01/31/2005 from David Tyner): Should be "$(y^1, \dots, y^m)$" rather than "$(y^1, \dots, y^n)$".
13. Page 74, u9 (27/09/2005 from Bahman Gharesifard): Missing parenthesis.
14. Page 78, u10 (03/10/2005 from Cesar Aguilar): "$\mathscr{A} = \{\mathcal{U}_a, \phi_a\}_{a \in A}$" should be "$\mathscr{A} = \{(\mathcal{U}_a, \phi_a)\}_{a \in A}$".
15. Page 95, d18 (28/05/2008 from Jorrit Kirsten): Should be "$A_X(x_0)$ the ***linearization***".
16. Page 104, u19 (21/05/2008 from Jorrit Kirsten): "pointwise assignments" should be "pointwise assignment".
17. Page 109, d2 (21/05/2008 from Jorrit Kirsten): "If $\mathcal{D}$ is a distribution" should be "If $\mathcal{D}$ is a C^r-distribution".
18. Page 127, u17 (04/11/2004): "it is" should be "is it".
19. Page 127, u6 (04/11/2004): "it is" should be "is it".
20. Page 133, d21 (22/12/2005): The proper formula for the components of the curvature tensor is

$$R^i_{jkl} = \frac{\partial \Gamma^i_{lj}}{\partial x^k} - \frac{\partial \Gamma^i_{kj}}{\partial x^l} + \Gamma^i_{km}\Gamma^m_{lj} - \Gamma^i_{lm}\Gamma^m_{kj}, \qquad i, j, k, l \in \{1, \dots, n\}.$$

    This uses the rule $R(\frac{\partial}{\partial x^k}, \frac{\partial}{\partial x^l})\frac{\partial}{\partial x^j} = R^i_{jkl}\frac{\partial}{\partial x^i}$.
21. Page 135, u6 (10/02/2004 from David Tyner): Change "these operations make $\mathsf{T}_x\mathsf{M}$ is $\mathbb{R}$-vector space" to "these operations make $\mathsf{T}_x\mathsf{M}$ a $\mathbb{R}$-vector space".
22. Page 137, d8 (13/02/2006): Replace "$\Gamma^\infty(\mathsf{M})$" with "$\Gamma^\infty(\mathsf{TM})$".
23. Page 137, u13 (01/02/2006): Replace "this outlined" with "this is outlined".
24. Page 154, d11 (06/02/2006 from Thomas Norman): A "$\times$" is missing between $\mathbb{R}^2$ and $]-\pi, \pi[$.
25. Page 156, d6 (04/11/2004): Replace "for the body $(\mathcal{B}_a, \mu_a)$" with "for the ath body".
26. Page 158, d6 (08/03/2005 from Cesar Aguilar): Should read "$(\boldsymbol{R}_0^T \boldsymbol{A}_{\boldsymbol{R}_0})^T = -\boldsymbol{R}_0^T \boldsymbol{A}_{\boldsymbol{R}_0}$".
27. Page 158, u14 (09/03/2005 from Cesar Aguilar): The statement "$\mathsf{SO}(3)$ is trivializable" should be "$\mathsf{SO}(3)$ is parallelizable".
28. Page 159, d5 and d8 (12/04/2005 from John Mardlin): Swap "λ" and "ρ" in the two displayed equations.
29. Page 169, u2 (01/12/2004): It is more consistent to say "$\boldsymbol{b}_3$" rather than "$\boldsymbol{s}_3$". Also, the explicit expression for the inertia tensor can be given as

$$[\mathbb{I}_{\mathrm{c}}] = \begin{bmatrix} * & * & 0 \\ * & * & 0 \\ 0 & 0 & J \end{bmatrix},$$

    where an "$*$" means a term whose value is immaterial.
30. Page 170, d19 (01/12/2004): It is more consistent to say "$\boldsymbol{b}_3$" rather than "$\boldsymbol{s}_3$". Also, the explicit expressions for the inertia tensors can be given as

$$[\mathbb{I}_{1,\mathrm{c}}] = \begin{bmatrix} * & * & 0 \\ * & * & 0 \\ 0 & 0 & J_1 \end{bmatrix}, \quad [\mathbb{I}_{2,\mathrm{c}}] = \begin{bmatrix} * & * & 0 \\ * & * & 0 \\ 0 & 0 & J_2 \end{bmatrix},$$

    where an "$*$" means a term whose value is immaterial.

31. Page 175, u13 (21/05/2008 from Jorrit Kirsten): "as can be see in the proof" should be "as can be seen in the proof".
32. Page 175, u15 (01/10/2004): The sentence should read, "This is referred to as ***Hamilton's Principle***, with the original contributions appearing in [**??**]." The papers of **?** should also be added to the bibliography.
33. Page 175, u11 (22/02/2006): The expression in the displayed equation should be set equal to zero.
34. Page 181, u1 (26/04/2007 from Elliot Johnson): Replace "m_2^1" with "m_2^2".
35. Page 189, d15 (18/04/2005 from David Tyner): Replace "$\boldsymbol{\omega}_a$" with "$\widehat{\boldsymbol{\omega}}_a$".
36. Page 195, u11 (21/05/2008 from Jorrit Kirsten): Set this equation to be equal to zero.
37. Page 196, d18 (21/05/2008 from Jorrit Kirsten): Set this equation to be equal to zero.
38. Page 196, u5 (21/05/2008 from Jorrit Kirsten): Replace "call at a" with "call it a".
39. Page 197, d10 (21/05/2008 from Jorrit Kirsten): Add the factor a_g to the last term in this expression.
40. Page 201, d8 (04/11/2004): Replace both occurrences of "regular" with "of class C^r".
41. Page 210, u13 (28/05/2008 from Jorrit Kirsten): Add condition that $X \in \Gamma^\infty(\mathsf{TM})$.
42. Page 230: u20 (04/11/2004): Replace "make" with "made".
43. Page 232– (09/04/2006 from Thomas Norman): In part (e) of exercises E4.3, E4.4, E4.5, E4.6, E4.7, E4.8, and E4.9, replace "$\iota_{\text{body}}|\mathsf{Q}$" and $\iota_{\text{spatial}}|\mathsf{Q}$" with "$\iota_{\text{body}}|\mathsf{TQ}$" and $\iota_{\text{spatial}}|\mathsf{TQ}$", respectively.
44. Page 239, d16 (28/05/2008 from Jorrit Kirsten): Should be " the work done by the gyroscopic force"
45. Page 239, d17 (17/01/2005 from David Tyner): "$E(v_q) = \frac{1}{2}\mathbb{G}(v_q, v_q) - V(q)$" should be "$E(v_q) = \frac{1}{2}\mathbb{G}(v_q, v_q) + V(q)$".
46. Page 258, d1 (10/03/2005 from Cesar Aguilar): The domain and range of Eul^{-1} should be switched.
47. Page 259, d13 (08/09/2004): Extra parenthesis removed from the end of the line.
48. Page 262, u8-9 (22/11/2004): Change "$o(t^2)$" to "$O(t^2)$" and "$o(t^3)$" to "$O(t^3)$". Also, remove the bit where the definition of "o" is recalled.
49. Page 287, u11 (07/09/2004): "fiber bundle map on TM" should be replaced with "fiber bundle map from TM to $\mathsf{T}^*\mathsf{M}$ over id_M".
50. Page 290, proof of Proposition 6.54 (16/02/2005): Replace all occurrences of "$\langle\!\langle \cdot, \cdot \rangle\!\rangle$" with "$\mathbb{G}(\cdot, \cdot)$".
51. Page 291, Definition 5.68 (16/02/2005): Replace all occurrences of "$\langle\!\langle \cdot, \cdot \rangle\!\rangle$" with "$\mathbb{G}(\cdot, \cdot)$".
52. Page 292, proof of Theorem 5.69 (16/02/2005): Replace all occurrences of "$\langle\!\langle \cdot, \cdot \rangle\!\rangle$" with "$\mathbb{G}(\cdot, \cdot)$".
53. Page 294, d12 (16/08/2007 from Pantelis Isaiah): "(r, θ_1, θ_2)" should read "(r, θ, ψ)".
54. Page 296, d13 (16/02/2005): Replace "$\langle\!\langle \xi_{\text{R}}(g), v_g \rangle\!\rangle$" with "$\mathbb{G}_{\mathbb{I}}(\xi_{\text{R}}(g), v_g)$".
55. Page 297, u15 (07/09/2004): Replace "where" with "for which".
56. Page 302, u4 (16/12/2006): Replace "$\overset{\mathbb{G}}{\nabla}_{\text{hlft}(X)} Y_k$" with "$\overset{\mathbb{G}}{\nabla}_X \text{hlft}(Y_k)$".,

57. Page 305, u6 (11/05/2005 from Cesar Aguilar): Should read "$\exp(\boldsymbol{A})\boldsymbol{B} = \boldsymbol{B}\exp(\boldsymbol{A})$".
58. Page 320, d3 (23/03/2007): Replace "intersection with $\mathbb{R} \setminus \bar{B}_r(x_0)$" with "intersection with $\mathbb{R}^n \setminus \bar{B}_r(x_0)$".
59. Page 326, d16 (22/11/2004): Change "$o\big(\|(x^1, \dots, x^n)\|^3_{\mathbb{R}^n}\big)$" to "$O\big(\|(x^1, \dots, x^n)\|^3_{\mathbb{R}^n}\big)$".
60. Page 333, d5 (13/01/2005 from David Tyner): "$L(\mathsf{T}_{q_0}; \mathsf{T}^*_{q_0}\mathsf{Q})$" should be "$L(\mathsf{T}_{q_0}\mathsf{Q}; \mathsf{T}^*_{q_0}\mathsf{Q})$".
61. Page 349, d18 (22/01/2005): There is no reason why constraints cannot be included in the definitions for relative equilibria and their stability. This is done here by replacing "$\Sigma = (\mathsf{Q}, \mathbb{G}, V, F)$" with "$\Sigma = (\mathsf{Q}, \mathbb{G}, V, \mathcal{D}, F)$". See item 65 for the other change that needs to be made.
62. Page 350, d4 (16/02/2005): Should be "$T\pi_{\mathsf{B}} \circ \gamma'(t)$".
63. Page 350, d8 (16/02/2005): Should be "$T\pi_{\mathsf{B}} \circ \gamma'(t)$".
64. Page 350, d14 (16/01/2005): Add a comma after "fiber stable".
65. Page 351, d18 (22/01/2005): There is no reason why constraints cannot be included in the definitions for relative equilibria and their stability. This is done here by making the first sentence in this section, "Next, we endeavor to provide existence and stability criteria for a relative equilibrium of a C^∞-forced simple mechanical system $\Sigma = (\mathsf{Q}, \mathbb{G}, V, F)$ where F is time-independent." See item 61 for the other change that needs to be made.
66. Page 351, u9 (05/09/2004): Added comma to the end of the line.
67. Page 351, u2 (16/02/2005): Change "$\langle\!\langle v_q, X(q) \rangle\!\rangle$" to "$\mathbb{G}(v_q, X(q))$".
68. Page 353, d4 (16/02/2005): Replace "$V^{\text{eff}}_{X,v}$" with "$V^{\text{eff}}_{X,v(t)}$".
69. Page 353, u8 (16/12/2004): The "on the dynamical system" is better as "for the dynamical system".
70. Page 354, d16 (16/02/2005): Item (ii) in the statement of the lemma should begin "if q_0 is a critical point for ψ, then..."
71. Page 354, d19 (15/12/2004): The beginning of the proof does not need to say what is being proved.
72. Page 354, u15 (22/11/2004): Change "$o\big(\|(q^1, \dots, q^n)\|^3_{\mathbb{R}^n}\big)$" to "$O\big(\|(q^1, \dots, q^n)\|^3_{\mathbb{R}^n}\big)$".
73. Page 360, Figure 6.9 (16/12/2006): The figure has been altered; it is confusing as it is.
74. Page 362, u9 (20/04/2006): Change "converges to a critical point" to "converges to a connected component of the set of critical points".
75. Page 373, u4 (09/04/2006 from Bahman Gharesifard): Change "an family" to "a family."
76. Page 378, d8 (01/08/2007 from Cesar Aguilar): The interior in this equation should be relative to
$$\text{aff}\Big\{ f_0(x_0) + \sum_{a=1}^m u^a f_a(x_0) \;\Big|\; u \in U \Big\}.$$
77. Page 382, u14 (01/07/2005 from Cesar Aguilar): In fact, $[\xi_1, [\xi_0, \xi_1]] + [\xi_2, [\xi_0, \xi_2]]$ *is* in $\mathcal{B}^{\boldsymbol{w}}(\boldsymbol{\xi})$ when $\boldsymbol{w} = (1, 1, 3)$.
78. Page 387, d16 (09/04/2006 from Bahman Gharesifard): Should be "$\mathcal{D}_{\gamma(t_0)}$" rather than the garble that is there.
79. Page 449, d5 (04/11/2004): Should be "using the variation of constants formula".

80. Page 483, u5 (05/09/2004): Added some commas to arrive at "if, in part (vii), one can take".
81. Page 488, d21 (15/01/2007 from Elsa Hansen): Replace "there are systems that do not satisfy the necessary conditions, but are nonetheless locally asymptotically stabilizable by C^0-state feedback" with "there are systems that satisfy the necessary conditions, but are nonetheless not locally asymptotically stabilizable by C^0-state feedback".
82. Page 497, d12 (25/09/2004): Should be "$K_{\mathrm{P}}^\sharp$" and "$K_{\mathrm{D}}^\sharp$".
83. Page 498, u3 (25/09/2004): Should be "$K_{\mathrm{P}}^\sharp$" and "$K_{\mathrm{D}}^\sharp$".
84. Page 502, u12 (25/09/2004): Should be "$K_{\mathrm{P}}^\sharp$" and "$K_{\mathrm{D}}^\sharp$".
85. Page 503, d13 (25/09/2004): Should be "$K_{\mathrm{P}}^\sharp$".
86. Page 503, d14 (22/01/2005): Add a comma after "Furthermore".
87. Page 509, d14 (23/09/2004): The sentence should read: "That is to say, if K_{D} is positive-definite, then derivative control of a simple mechanical system is an example of dissipative control for the corresponding control-affine system."
88. Page 512, u14 (23/09/2004): The sentence here reads better as, "We now state a sufficient condition for stabilizability by PD control."
89. Page 513, d6 (27/09/2004): Should be "$F_{\mathsf{B}}^*(b)$".
90. Page 563, d18 (06/09/2004): Replace "analog" with "analogous".
91. Page 603, d10 (16/02/2005): Replace both occurrences of "$\langle\!\langle \cdot, \cdot \rangle\!\rangle$" with "$\mathbb{G}(\cdot, \cdot)$".
92. Page 621, u9 (10/11/2004): This item should be replaced with, "A property P holds ***almost everywhere*** (***a.e.***) on I, or for ***almost every*** $\boldsymbol{t \in I}$ (***a.e.*** $\boldsymbol{t \in I}$) if there exists a subset $N \subset I$ of zero measure such that P holds for all $t \in I \setminus N$."
93. Page 667, u10 (21/05/2008 from Jorrit Kirsten): Replace "Grundgesatz" with "Grundgesetz".
94. Page 671, d15 and d18 (21/05/2008 from Jorrit Kirsten): Replace "Dynamics" with "Dynamik"
95. Page 673, d1 (21/05/2008 from Jorrit Kirsten): Replace "Rotationskorpers" with "Rotationskörpers" and "Flussigkeit" with "Flüssigkeit".
96. Page 679, u5 (17/01/2006): Should be "Lie" and not "lie".
97. Page 681, d6 (17/12/2004): The title should be appropriately capitalized, and it is "number", not "volume".