Logic in Computer Science

Modelling and Reasoning about Systems*

Errata for the **First** Printing of the **First** Edition

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Readers of this book are kindly requested to notify Michael Huth (email: `huth@cis.ksu.edu`) of errors they find. These will be included in this file, and incorporated into a second edition that is already in planning.

- p. 15, line 11, "assumption" should read "premise".
- p. 25, Example 1.20, the first line of that proof should be annotated as "premise".
- p. 29, the proof on that page and the subsequent sentence should read:

1	$\neg\phi \to \bot$	given
2	$\neg\phi$	assumption
3	$\bot$	$\to$e $1, 2$
4	$\neg\neg\phi$	$\neg$i $2-3$
5	ϕ	$\neg\neg$e 4

This shows that RAA can be derived from $\to$i, $\to$e, $\neg$i, and $\neg\neg$e.

(That is to say, the proof rule on line 3 is $\to$e and not $\neg$e.)

- p. 37, line 12, $(n \geq 1)$ should be $(n \geq 0)$ as the sequence may be empty.

*Cambridge University Press, 2000.

- p. 42, line 11, the subformula $((p \wedge (q \vee (\neg p)))$ should really read $((p \wedge (q \vee (\neg r)))$.

- p. 57–60, the soundness proof: the formal notion of a "modified proof" is problematic and does not pass formal muster (courtesy of James Caldwell). Our apologies! At any rate, the inductive argument can still be appreciated with an intuitive understanding of "modified proofs". We mean to re-write the definition of "modified proof" in the second, upcoming edition.

- p. 64, line 19. Then sentence "Second, if ϕ evaluates to `F` and ..." should read "Second, if ϕ_1 evaluates to `F` and ...".

- p. 64, line 5 from below: $\neg\phi_1 \wedge \neg\phi_2 \vdash \neg\phi_1 \wedge \phi_2$ should read $\neg\phi_1 \wedge \neg\phi_2 \vdash \neg(\phi_1 \wedge \phi_2)$.

- p. 71, Exercise 3: The second sentence should read "For example, the set $\{\neg, \vee\}$ is adequate for propositional logic, because any occurrence of $\wedge$ and $\rightarrow$ can be removed by using the equivalences

$$\begin{aligned} \phi \rightarrow \psi &\equiv \neg\phi \vee \psi \\ \phi \wedge \psi &\equiv \neg(\neg\phi \vee \neg\psi).'' \end{aligned}$$

- p. 74, the sentence, beginning in line 7 with "We simply form..." does not contain anything that is technically incorrect, but it sounds confusing when we read it now. Our apologies!

- p. 79, line 17: The sentence should read "The case when η_2 is a conjunction is symmetric and the structure of the recursive call of `DISTR` is then dictated by the equivalence

$$\eta_1 \vee \eta_2 \equiv (\eta_1 \vee \eta_{21}) \wedge (\eta_1 \vee \eta_{22}),''$$

- p. 91, line 21: Variables are written

$$u, v, w, x, y, z, \ldots \qquad \text{or} \qquad x_1, y_3, u_5, \ldots$$

- p. 95, lines 2 and 7 from below: the occurrences of $B(m, x)$ should read $B(x, m)$; note that B is an asymmetric relation unlike "being siblings".

- p. 102, Exercise 4(b): "If the Jayhawks beat the Wildcats, then the Jayhawks do not lose to every football team."
- p. 102, Exercise 7(b): "crawfish étoufée" should read "crawfish étouffée" (milles excuses!).
- p. 103, Exercise 7(d): "Elis Marsalis" should read "Ellis Marsalis".
- p. 108, line 3: "t is free in x for ϕ" should read "t is free for x in ϕ".
- p.121, lines 15–16, Theorem 2.9.2: We should have stated two more equivalences which are dual to the ones in (e) and (f):

  (g) $\exists x(\psi \to \phi) \dashv\vdash \psi \to \exists x\phi$

  (h) $\forall x(\phi \to \psi) \dashv\vdash \exists x\phi \to \psi$.
- p. 124: The two proofs for item 2(a) begin with a "premise", not an "assumption"; in the latter case, we would have to open boxes and would not be able to show what is required.
- p. 125, the proof of Theorem 2.9.4b should read:

1		$\exists x\, \exists y\, \phi$	premise
2	x_0	$(\exists y\, \phi)[x_0/x]$	assumption
3		$\exists y\, (\phi[x_0/x])$	identical, since x, y different variables
4	y_0	$\phi[x_0/x][y_0/y]$	assumption
5		$\phi[y_0/y][x_0/x]$	identical, since x, y, x_0, y_0 different variables
6		$\exists x\, \phi[y_0/y]$	$\exists x$ i 5
7		$\exists y\, \exists x\, \phi$	$\exists y$ i 6
8		$\exists y\, \exists x\, \phi$	$\exists y$ e 3, 4–7
9		$\exists y\, \exists x\, \phi$	$\exists x$ e 1, 2–8

- p. 127, Exercise 9(e) is the same as Exercise 9(d).
- p. 128, Exercise 11(c): the sequent

$$\forall x\, (P(x) \to (Q(x) \lor R(x))),\ \neg\exists x\, (P(x) \land R(x)) \vdash \forall x\, P(x) \to Q(x)$$

should read

$$\forall x\,(P(x) \to (Q(x) \vee R(x))),\ \neg\exists x\,(P(x) \wedge R(x)) \vdash \forall x\,(P(x) \to Q(x))$$

(recall the binding priorities from Convention 2.3)

- p. 128, Exercise 11(e): This sequent is not valid, i.e. cannot have a proof: what if $P(x)$ is false for all x?
- p. 128, Exercise 11(f): the sequent

  $$\exists x\,(P(x) \wedge Q(x)),\ \forall y\,(P(x) \to R(x)) \vdash \exists x\, R(x) \wedge Q(x)$$

  should read

  $$\exists x\,(P(x) \wedge Q(x)),\ \forall y\,(P(x) \to R(x)) \vdash \exists x\,(R(x) \wedge Q(x)),$$

  i.e. the last formula is an existential quantification of a conjunction (recall the binding priorities from Convention 2.3).
- p. 131, Example 2.11, the set of function symbols $\mathcal{F}$ should read $\{+, *, -\}$.
- p. 132, line 4: the formula

  $$\forall x\,(x \leq x \cdot e) \wedge (x \cdot e \leq x)$$

  should read

  $$\forall x\,((x \leq x \cdot e) \wedge (x \cdot e \leq x))$$

  i.e. the latter formula is a universal quantification of a conjunction (recall the binding priorities from Convention 2.3).
- p. 132, line 16 from below, "and s_3 to be 0" should read "and s to be 0".
- p. 135, line 6, "chose" should read "choose".
- p. 135, the sentence beginning on line 7 should read:

  > Since (a, a) is in the set $\mathsf{loves}^{\mathcal{M}}$ and (b, a) is in the set $\mathsf{loves}^{\mathcal{M}}$, we would need that the latter does not hold since it is the interpretation of $\mathsf{loves}(y, \mathsf{alma})$; this cannot be.

That is, the second pair is (b, a), the interpretation of loves(y,x), and not (a, a). (Alternatively, one may choose a for y.)

- p. 135, line 12–13, Example 2.15: The statement "Well, now there is exactly one lover of Alma's lovers, namely c" is incorrect; b is still a lover of Alma's lovers, as before. So line 12 should read

$$\text{“}\mathsf{loves}^{\mathcal{M}'} \stackrel{\text{def}}{=} \{(b, a), (c, b)\}''$$

for the example to work correctly.

- p. 138, line 6: the occurrence of "that" should be "what".
- p. 143, line -9, Proof of Theorem 2.17: "gives us" should be "tells us there is"
- p. 144, line 18, Proof of Theorem 2.17: "gives us" should be "tells us there is"
- p. 146, line -21–-13, Exercise 2 is the same as Exercise 2.7.7.
- p. 151, line 12, "prefect" should read "perfect".
- p. 158, items 13 and 14, the two occurrences of "ϕ *Until* ψ" should read "ϕ_1 *Until* ϕ_2".
- p. 167, equation (3.3) is parametric in ϕ and ψ:

$$\mathrm{A}[\phi \ \mathrm{U} \ \psi] \ \equiv \ \neg(\mathrm{E}[\neg\psi \ \mathrm{U} \ (\neg\phi \land \neg\psi)] \lor \mathrm{EG}\,\neg\psi).$$

- p. 167, line 8 from below: "Similarly, AG, AU and AX form an adequate set." This is incorrect. For details see http://www.lsv.ens-cachan.fr/Publis/PAPERS/Lar-IPL95.ps.
- p. 179, function SAT, the brackets in $\mathrm{A}(\phi_1 \ \mathrm{U} \ \phi_2)$ and $\mathrm{E}(\phi_1 \ \mathrm{U} \ \phi_2)$ should be $\mathrm{A}[\phi_1 \ \mathrm{U} \ \phi_2]$ and $\mathrm{E}[\phi_1 \ \mathrm{U} \ \phi_2]$.
- p. 182, line 15, "`status` of type `ready, busy`:" should read "`status` of type {`ready, busy`}:".
- p. 183, line 8 from below, "the module `counter`" should read "the module `counter_cell`".

- p. 184, line 15, "`value + carry_in mod 2`" should read

  "`(value + carry_in) mod 2`".

- p. 187, Figure 3.24:
  - The arrow from `cn0` to `cn0` should be labelled by 2, not by $1, 2$. Also, there should be an arrow from `cn0` to `cn1` labelled by 1.
  - Symmetrically, the arrow from `nc1` to `nc1` should be labelled by 1, not $1, 2$. There should be an arrow from `nc1` to `nc0` labelled by 2.

- p. 195, Figure 3.29, "$\vDash \mathrm{E}_f \mathrm{G}\, \phi$" should read "$\vDash \mathrm{E}_C \mathrm{G}\, \phi$".

- p. 197, line 3 from below: the formula $F\, q$ should read $F\, \psi$.

- p. 207, line 14, "we see that $F^{n+1}(0)$ would have" should read "we see that $F^{n+2}(0)$ would have".

- p. 253, Example 4.14: claims that the array $[4, -8, 3, -4, 8, -6, -3, 5]$ has two minimal-sum sections with minimal sum -9. But it has only one minimal-sum section with sum -10.

- p. 255, lower half of that page: Several occurrences of "$k + 1$" should be "$k - 1$". This may possibly apply to the occurrences of "$k + 1$" on pages 256–257. Please see the course home page at

  `http://www.cis.ksu.edu/~huth/301/home.html`

  for a more transparent treatment of this problem.

- p. 255, line 12 from below: "the final value of n is $k + 1$" should read "the final value of k is $n + 1$".

- p. 255 to p. 266: in all displayed formulas it is understood that i and j are at least 1.

- p. 274, line 10 from below, "$R(x_1, x_2)$" should read "$R(x_2, x_1)$".

- p. 275, caption of Table 5.7: The term "valid" has a reserved technical meaning, the one given in Definition 5.8 on page 269. In this table, "valid" has that meaning, but restricted to those models that reflect the intuition of $\Box\phi$ as indicated in the columns of that table.

- p. 279, line 4, "$R(y,z))$" should read "$R(y,z)$".
- p. 324, the last sentence on that page should read:

  > The solid link from the leftmost x to the 1-terminal is never taken, for example, because one can only get to that x-node when x has value 0.

  (That is to say, we are not talking about the link to the 0-terminal.)
- p. 332, Figure 6.13: the dashed line emanating from the rightmost x_5 node reaches the x_6 node, not the rightmost x_4 node. That is to say, this line should bend around the x_4 node.
- p. 353, Figure 6.27, the second row from below in that table should read

set of states	representation by boolean values	representation by boolean function
$\{s_1, s_2\}$	$(0,1),(0,0)$	$\overline{x_1} \cdot x_2 + \overline{x_1} \cdot \overline{x_2}$

- p. 354, Figure 6.29(a) has a missing arrowhead; the transition between s_1 and s_3 goes from s_1 to s_3: $s_1 \longrightarrow s_3$.
- p. 368, lines 4–7 should read:

  The coding of AF is similar to the one for EF in (6.17), except that 'for some' (boolean quantification $\exists\hat{x}'$) gets replaced by 'for all' (boolean quantification $\forall\hat{x}'$) and the "conjunction" $f^{\rightarrow} \cdot Z[\hat{x} := \hat{x}']$ turns into the "implication" $\overline{f^{\rightarrow}} + Z[\hat{x} := \hat{x}']$:

  $$f^{\mathrm{AF}\,\phi} \stackrel{\mathrm{def}}{=} \mu Z.\,(f^{\phi} + \forall\hat{x}'.\,(\overline{f^{\rightarrow}} + Z[\hat{x} := \hat{x}'])). \tag{1}$$

- p. 372, equation (6.24): the occurrences of ϕ and ψ should read ϕ_1 and ϕ_2, respectively.
- p. 374, line 8: the formula (6.28) should read

  $$\mu Y.(f^{\rightarrow} + \exists\hat{w}.(Y[\hat{x}' := \hat{w}] \cdot Y[\hat{x} := \hat{w}])).$$

- p. 374, line 11–12: The informal explanation should read:

If we apply (6.12) m times to the formula in (6.28), then this has the same semantic 'effect' as applying this rule 2^m times to `checkEU` $(f^{\rightarrow}, \top)$.

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