

# References

1. ACEMS: The Australian research council (arc) centre of excellence for mathematical and statistical frontiers (2014). URL [www.acems.org.au/](http://www.acems.org.au/)
2. Agarwal, R., Dhar, V.: Editorial-Big data, data science, and analytics: The opportunity and challenge for IS research. *Information Systems Research* **25**(3), 443–448 (2014)
3. Agency, X.N.: The 13th five-year plan for the national economic and social development of the peoples' republic of China (2016). URL [http://news.xinhuanet.com/politics/2016lh/2016-03/17/c\\_1118366322.htm](http://news.xinhuanet.com/politics/2016lh/2016-03/17/c_1118366322.htm)
4. AGIMO: AGIMO big data strategy - issues paper (2013). URL [www.finance.gov.au/files/2013/03/Big-Data-Strategy-Issues-Paper1.pdf](http://www.finance.gov.au/files/2013/03/Big-Data-Strategy-Issues-Paper1.pdf)
5. Anderson, P.E., Bowring, J.F., McCauley, R., Pothering, G., Starr, C.W.: An undergraduate degree in data science: Curriculum and a decade of implementation experience. In: *Computer Science Education: Proceedings of the 45th ACM Technical Symposium (SIGCSE'14)*, pp. 145–150 (2014)
6. Anderson, P.E., Turner, C., Dierksheide, J., McCauley, R.: An extensible online environment for teaching data science concepts through gamification. In: *2014 IEEE Frontiers in Education Conference (FIE)*, pp. 1–8 (2014)
7. Anya, O., Moore, B., Kieliszewski, C., Maglio, P., Anderson, L.: Understanding the practice of discovery in enterprise big data science: An agent-based approach. In: *6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences*, vol. 3, pp. 882–889 (2015)
8. Apache: Apache opennlp (2016). URL <https://opennlp.apache.org/>
9. Apache: Apache spark mllib (2016). URL <http://spark.apache.org/mllib/>
10. Apache: The apache software foundation (2018). URL <https://www.apache.org/>
11. ARC: Codes and guidelines | Australian research council (2017). URL [www.arc.gov.au/codes-and-guidelines](http://www.arc.gov.au/codes-and-guidelines)
12. ASA: ASA views on data science (2015). URL <http://magazine.amstat.org/?s=data+science&x=0&y=0>
13. ASA: Ethical guidelines for statistical practice, American statistical association (2016). URL <https://www.certifiedanalytics.org/ethics.php>
14. AU: Data-matching program (1990). URL <http://www.comlaw.gov.au/Series/C2004A04095>
15. AU: Declaration of open government (2010). URL <http://agimo.gov.au/2010/07/16/declaration-of-open-government/>
16. AU: Attorney-General's department (2013). <http://www.attorneygeneral.gov.au/Mediareleases/Pages/2013/Second%20quarter/22May2013-AustraliajoinsOpenGovernmentPartnership.aspx>

17. AU: Australia big data (2016). URL <http://www.finance.gov.au/big-data/>
18. Auschitzky, E., Hammer, M., Rajagopaul, A.: How big data can improve manufacturing? (2016). URL <http://www.mckinsey.com/business-functions/operations/our-insights/how-big-data-can-improve-manufacturing>
19. Ayankoya, K., Calitz, A., Greyling, J.: Intrinsic relations between data science, big data, business analytics and datafication. ACM International Conference Proceeding Series **28**, 192–198 (2014)
20. Bailer, J., Hoer, R., Madigan, D., Montaquila, J., Wright, T.: Report of the asa workgroup on master's degrees (2012). URL <http://magazine.amstat.org/wp-content/uploads/2013an/masterworkgroup.pdf>
21. Barber, D.: Bayesian Reasoning and Machine Learning. Cambridge University Press (2012)
22. Batini, C., Scannapieco, M.: Data and Information Quality: Dimensions, Principles and Techniques. Springer (2016)
23. Baumer, B.: A data science course for undergraduates: Thinking with data. The American Statistician **69**(4), 334–342 (2015)
24. BBC: Facebook-Cambridge analytica data scandal (2018). URL <http://www.bbc.com/news/topics/c81zyn0888lt/facebook-cambridge-analytica-data-scandal>
25. BDL: Big data landscape (2016). URL [www.bigdatalandscape.com](http://www.bigdatalandscape.com)
26. BDL: Big data landscape 2016 (version 3.0) (2016). URL <http://mattturck.com/2016/02/01/big-data-landscape/>
27. BDSS: Big data social science. URL <http://bdss.psu.edu/>
28. BESS: Behavioral, economic, socio-cultural computing. URL <http://www.behaviorinformatics.org/>
29. Beyer, M.A., Laney, D.: The importance of 'big data': A definition (2012). URL <https://www.gartner.com/doc/2057415>. Gartner
30. Bhardwaj, A., Bhattacharjee, S., Chavan, A., Deshp, A., Elmore, A.J., Madden, S., Parameswaran, A.: Datahub: Collaborative data science & dataset version management at scale. In: In CIDR (2015)
31. BI: Behavioral insights (2014). URL <http://www.behaviouralinsights.co.uk/>
32. BigML: Bigml (2016). URL <https://bigml.com/>
33. BIID: Beyond iid in information theory (biid) workshop (2013). URL <https://sites.google.com/site/beyondiid4/biid-conference-series>
34. Boccara, N.: Modeling Complex Systems. Springer (2003)
35. Bono, E.D.: Lateral Thinking: Creativity Step by Step. Harper & Row (1970)
36. Borne, K.D., Jacoby, S., Carney, K., Connolly, A., Eastman, T., Raddick, M.J., Tyson, J.A., Wallin, J.: The revolution in astronomy education: Data science for the masses (2010). URL <http://arxiv.org/pdf/0909.3895v1.pdf>
37. Bothun, D., Vollmer, C.A.H.: 2016 entertainment & media industry trends (2016). URL <https://www.strategyand.pwc.com/media/file/2016-Entertainment-and-Media-Trends.pdf>
38. Boulding, K.: Notes on the information concept. Exploration (Toronto) **6**(103-112, CP IV), 21–32 (1955)
39. Boyer, S., Gelman, B.U., Schreck, B., Veeramachaneni, K.: Data science foundry for MOOCs. In: IEEE International Conference on Data Science and Advanced Analytics (DSAA), pp. 1–10 (2015)
40. BPMM: Business process maturity model<sup>TM</sup> (bpmm<sup>TM</sup>) (2008). URL <http://www.omg.org/spec/BPMM/>
41. Brain, G.: Tensorflow (2016). URL <https://www.tensorflow.org/>
42. Breiman, L.: Statistical modeling: The two cultures. Statist. Sci. **16**(3), 199–231 (2001)
43. Brockman, J.: What to Think About Machines That Think: Today's Leading Thinkers on the Age of Machine Intelligence. Harper Perennial (2015)
44. Broman, K.: Data science is statistics (2013). URL <https://kbroman.wordpress.com/2013/04/05/data-science-is-statistics/>

45. Brown, G.: Review of education in mathematics, data science and quantitative disciplines: Report to the group of eight universities (2009). URL <https://go8.edu.au/publication/go8-review-education-mathematics-data-science-and-quantitative-disciplines>
46. Burnes, J.: 10 steps to improve your communication skills. URL <https://www.aim.com.au/blog/10-steps-improve-your-communication-skills>
47. Burch, L.: The burch works study: Salaries of data scientists (2014). URL [http://www.burchworks.com/files/2014/07/Burch-Works-Study\\_DS\\_final.pdf](http://www.burchworks.com/files/2014/07/Burch-Works-Study_DS_final.pdf)
48. Bussaban, K., Waraporn, P.: Preparing undergraduate students majoring in computer science and mathematics with data science perspectives and awareness in the age of big data. In: 7th World Conference on Educational Sciences, vol. 197, pp. 1443–1446 (2015)
49. Bynum, T.: Computer and information ethics. In: The Stanford encyclopedia of philosophy (ed. Zalta EN) (2015). URL See <http://plato.stanford.edu/archives/win2015/entries/ethics-computer/>
50. CA: Canada capitalizing on big data (2016). URL [http://www.sshrc-crsh.gc.ca/news\\_room-salle\\_de\\_presse/latest\\_news-nouvelles\\_recentes/big\\_data\\_consultation-donnees\\_massives\\_consultation-eng.aspx](http://www.sshrc-crsh.gc.ca/news_room-salle_de_presse/latest_news-nouvelles_recentes/big_data_consultation-donnees_massives_consultation-eng.aspx)
51. Campbell, J.D., Molines, K., Swarth, C.: Data mining for ecological field research: Lessons learned from amphibian and reptile activity analysis. In: NSF Symposium on Next Generation of Data Mining and Cyber-Enabled Discovery for Innovation (2007)
52. Campbell, J.: *Environmental Informatics*. <http://www.environmentalinformatics.com/Bibliography.php>
53. Cao, L.: Data Mining and Multi-agent Integration (edited). Springer (2009)
54. Cao, L.: Domain driven data mining: Challenges and prospects. *IEEE Trans. on Knowledge and Data Engineering* **22**(6), 755–769 (2010)
55. Cao, L.: In-depth behavior understanding and use: The behavior informatics approach. *Information Science* **180**(17), 3067–3085 (2010)
56. Cao, L.: Strategic recommendations on advanced data industry and services for the yanhuang science and technology park (2011)
57. Cao, L.: Actionable knowledge discovery and delivery. *Wiley Interdisc. Rew.: Data Mining and Knowledge Discovery* **2**(2), 149–163 (2012)
58. Cao, L.: Social security and social welfare data mining: An overview. *IEEE Trans. Systems, Man, and Cybernetics, Part C* **42**(6), 837–853 (2012)
59. Cao, L.: Combined mining: Analyzing object and pattern relations for discovering and constructing complex but actionable patterns. *WIREs Data Mining and Knowledge Discovery* **3**(2), 140–155 (2013)
60. Cao, L.: Non-iidness learning in behavioral and social data. *The Computer Journal* **57**(9), 1358–1370 (2014)
61. Cao, L.: Coupling learning of complex interactions. *J. Information Processing and Management* **51**(2), 167–186 (2015)
62. Cao, L.: *Metasynthetic Computing and Engineering of Complex Systems*. Springer (2015)
63. Cao, L.: Data science: A comprehensive overview. Submitted to *ACM Computing Survey* pp. 1–37 (2016)
64. Cao, L.: Data science: Challenges and directions (2016). Technical Report, UTS Advanced Analytics Institute
65. Cao, L.: Data science: Nature and pitfalls (2016). Technical Report, UTS Advanced Analytics Institute
66. Cao, L.: Data science: Profession and education (2016). Technical Report, UTS Advanced Analytics Institute
67. Cao, L.: *Data Science: Techniques and Applications* (2018)
68. Cao, L.: *Data Science Thinking: The Next Scientific, Technological and Economic Revolution*. Springer (2018)
69. Cao, L., Dai, R.: *Open Complex Intelligent Systems*. Post & Telecom Press (2008)

70. Cao, L., Dai, R., Zhou, M.: Metasynthesis: M-Space, M-Interaction and M-Computing for open complex giant systems. *IEEE Trans. On Systems, Man, and Cybernetics–Part A* **39**(5), 1007–1021 (2009)
71. Cao, L., Dong, X., Zheng, Z.: e-NSP: Efficient negative sequential pattern mining. *Artificial Intelligence* **235**, 156–182 (2016)
72. Cao, L., (Eds), P.S.Y.: *Behavior Computing: Modeling, Analysis, Mining and Decision*. Springer (2012)
73. Cao, L., Gorodetsky, V., Mitkas, P.A.: Agent mining: The synergy of agents and data mining. *IEEE Intelligent Systems* **24**(3), 64–72 (2009)
74. Cao, L., Ou, Y., Yu, P.S.: Coupled behavior analysis with applications. *IEEE Trans. on Knowledge and Data Engineering* **24**(8), 1378–1392 (2012)
75. Cao, L., Weiss, G., Yu, P.S.: A brief introduction to agent mining. *Autonomous Agents and Multi-Agent Systems* **25**(3), 419–424 (2012)
76. Cao, L., Yu, P.S., Kumar, V.: Nonoccurring behavior analytics: A new area. *IEEE Intelligent Systems* **30**(6), 4–11 (2015)
77. Cao, L., Yu, P.S., Zhang, C., Zhao, Y.: *Domain Driven Data Mining*. Springer (2010)
78. Cao, L., Zhang, C.: Knowledge actionability: Satisfying technical and business interestingness. *International Journal of Business Intelligence and Data Mining* **2**(4), 496–514 (2007)
79. Cao, L., Zhao, Y., Zhang, C.: Mining impact-targeted activity patterns in imbalanced data. *IEEE Trans. on Knowledge and Data Engineering* **20**(8), 1053–1066 (2008)
80. Cao, W., Cao, L.: Financial crisis forecasting via coupled market state analysis. *IEEE Intelligent Systems* **30**(2), 18–25 (2015)
81. Capterra: Top project management tools (2016). URL <http://www.capterra.com/project-management-software/>
82. Capterra: Top reporting software products (2016). URL <http://www.capterra.com/reporting-software/>
83. Casey, E.: The growing importance of data science in digital investigations. *Digital Investigation* **14**, A1–A2 (2015)
84. CBDIO: China big data industrial observation (2016). URL [www.cbdio.com](http://www.cbdio.com)
85. CCF-BDTF: China computer federation task force on big data (2013). URL <http://www.bigdataforum.org.cn/>
86. Ceglar, A., Roddick, J.: Association mining. *ACM Computing Surveys* **38**(2), 5 (2006)
87. Chambers, J.M.: Greater or lesser statistics: A choice for future research. *Statistics and Computing* **3**(4), 182–184 (1993)
88. Chandrasekaran, S.: *Becoming a data scientist* (2013). URL <http://nirvacana.com/thoughts/becoming-a-data-scientist/>
89. Chawla, S., Hartline, J., Nekipelov, D.: Mechanism design for data science. In: *Economics and computation: Proceedings of the Fifteenth ACM Conference*, pp. 711–712 (2014)
90. Chemuturi, M.: *Mastering Software Quality Assurance: Best Practices, Tools and Techniques for Software Developers*. J. Ross Publishing (2010)
91. Chen, H., Chiang, R.H.L., Storey, V.C.: Business intelligence and analytics: From big data to big impact. *MIS Quarterly* **36**(4), 1165–1188 (2012)
92. Chen, Z., Liu, B.: *Lifelong Machine Learning*. Synthesis Lectures on Artificial Intelligence and Machine Learning. Morgan & Claypool (2016)
93. Clancy, T.R., Bowles, K.H., Gelinias, L., Androwich, I., Delaney, C., Matney, S., Sensmeier, J., Warren, J., Welton, J., Westra, B.: A call to action: Engage in big data science. *Nursing Outlook* **62**(1), 64–65 (2014)
94. Classcentral: Data science and big data | free online courses (2016). URL <https://www.classcentral.com/subject/data-science>
95. Clauset, A., Larremore, D.B., Sinatra, R.: Data-driven predictions in the science of science. *Science* **355**, 477–480 (2017)
96. Clay, K.: Ces 2013: The year of the quantified self? (2013). URL <http://www.forbes.com/sites/kellyclay/2013/01/06/ces-2013-the-year-of-the-quantified-self/#4cf4d2b55e74>

97. Cleveland, W.S.: Data science: An action plan for expanding the technical areas of the field of statistics. *International Statistical Review* **69**(1), 21–26 (2001). doi:10.1111/j.1751-5823.2001.tb00477.x. URL <http://dx.doi.org/10.1111/j.1751-5823.2001.tb00477.x>
98. CMIST: China will establish a series of national labs (2016). URL <http://news.sciencenet.cn/htmlnews/2016/4/344404.shtml>
99. CNSF: National natural science foundation of China (2015). URL <http://www.nsf.gov.cn/>
100. Cohen, R., Havlin, S.: *Complex Networks: Structure, Robustness and Function*, 1st Edition. Cambridge University Press (2010)
101. Commission, E.: Commission urges governments to embrace potential of big data (2014). URL [www.europa.eu/rapid/press-release\\_IP-14-769\\_en.htm](http://www.europa.eu/rapid/press-release_IP-14-769_en.htm)
102. Commission, E.: Towards a thriving data-driven economy (2014). URL <https://ec.europa.eu/digital-single-market/en/towards-thriving-data-driven-economy>
103. Coursera: Coursera (2016). URL [www.coursera.org/data-science](http://www.coursera.org/data-science)
104. CRISP-DM: CRISP-DM (2016). URL [www.sv-europe.com/crisp-dm-methodology](http://www.sv-europe.com/crisp-dm-methodology)
105. Crowston, K., Qin, J.: A capability maturity model for scientific data management: Evidence from the literature. In: *Proceedings of the American Society for Information Science and Technology*, vol. 48, pp. 1–9 (2011)
106. CSC: Big data universe beginning to explode (2012). URL [http://www.csc.com/insights/flxwd/78931-big\\_data\\_growth\\_just\\_beginning\\_to\\_explode](http://www.csc.com/insights/flxwd/78931-big_data_growth_just_beginning_to_explode)
107. CSNSTC: Harnessing the power of digital data for science and society (2009). URL [https://www.nitrd.gov/About/Harnessing\\_Power\\_Web.pdf](https://www.nitrd.gov/About/Harnessing_Power_Web.pdf). Report of the Interagency Working Group on Digital Data to the Committee on Science of the National Science and Technology Council
108. CSS: Computational social science. URL <http://www.gesis.org/en/institute/gesis-scientific-departments/computational-social-science/>
109. Csurka, G.: Domain adaptation for visual applications: A comprehensive survey. *CoRR abs/1702.05374* (2017). URL <http://arxiv.org/abs/1702.05374>
110. CTM: Defining critical thinking (1987). URL <https://www.criticalthinking.org/pages/defining-critical-thinking/766>
111. Cummings, T., Jones, Y.: Creating actionable knowledge. URL <http://meetings.aonline.org/2004/theme.htm>
112. Cuzzocrea, A., Gaber, M.M.: Data science and distributed intelligence: Recent developments and future insights. *Studies in Computational Intelligence* **446**, 139–147 (2013)
113. DABS: Data analytics book series (2016). URL <http://www.springer.com/series/15063>
114. Dai, R., Wang, J., Tian, J.: *Metasynthesis of Intelligent Systems*. Zhejiang Sci. Technol. Press, Hangzhou, China (1995)
115. DARPA: DARPA xdata program (2016). URL [www.darpa.mil/program/xdata](http://www.darpa.mil/program/xdata)
116. Data61: Data61 (2016). URL <https://www.data61.csiro.au/>
117. DataRobot: Datarobot (2016). URL <https://www.datarobot.com/>
118. Datasciences.org: Datasciences.org (2005). URL [www.datasciences.org](http://www.datasciences.org)
119. Dataversity: How data scientists can improve communications skills. URL <http://www.dataversity.net/how-data-scientists-can-improve-communications-skills/>
120. Daumé III, H., Marcu, D.: Domain adaptation for statistical classifiers. *J. Artif. Int. Res.* **26**(1), 101–126 (2006)
121. Davenport, T.H., Patil, D.: Data scientist: The sexiest job of the 21st century. *Harvard Business Review* pp. 70–76 (2012)
122. Davis, J.: 10 programming languages and tools data scientists used (2016). URL <http://www.informationweek.com/devops/programming-languages/10-programming-languages-and-tools-data-scientists-use-now/d-d-id/1326034>
123. Deeplearning: Deeplearning (2016). URL [www.deeplearning.net/](http://www.deeplearning.net/)
124. Deo, N.: *Graph Theory with Applications to Engineering and Computer Science* (Prentice Hall Series in Automatic Computation). Prentice-Hall, Upper Saddle River, NJ, USA (1974)

125. Desale, D.: Top 30 social network analysis and visualization tools (2015). URL <http://www.kdnuggets.com/2015/06/top-30-social-network-analysis-visualization-tools.html>
126. Dhar, V.: Data science and prediction. *Communications of the ACM* **56**(12), 64–73 (2013)
127. Dierick, H.A., Gabbiani, F.: *Drosophila neurobiology: No escape from ‘big data’ science*. *Current Biology* **25**(14), 606–608 (2015)
128. Diggle, P.J.: Statistics: A data science for the 21st century. *Journal of the Royal Statistical Society: Series A (Statistics in Society)* **178**(4), 793–813 (2015)
129. Donoho, D.: 50 years of data science (2015). URL <http://courses.csail.mit.edu/18.337/2015/docs/50YearsDataScience.pdf>
130. Dorr, B.J., Greenberg, C.S., Fontana, P., Przybocki, M.A., Bras, M.L., Ploehn, C.A., Aulov, O., Michel, M., Golden, E.J., Chang, W.: The NIST data science initiative. In: 2015 IEEE International Conference on Data Science and Advanced Analytics (DSAA), pp. 1–10 (2015)
131. Dowden, B.H.: Logical Reasoning. Philosophy Department, California State University Sacramento (2017). URL <http://www.csus.edu/indiv/d/dowdenb/4/logical-reasoning.pdf>
132. Drew, C.: Data science ethics in government. *Phil. Trans. R. Soc. A* **374** (2016)
133. DSA: Data science association (2016). URL <http://www.datascienceassn.org/>
134. DSA: Data science code of professional conduct, data science association (2016). URL <http://www.datascienceassn.org/code-of-conduct.html>
135. DSAA: IEEE/ACM/ASA international conference on data science and advanced analytics (2014). URL [www.dsaa.co](http://www.dsaa.co)
136. DSC: College & university data science degrees (2016). URL <http://datascience.community/colleges> (accessed on 16 April 2016.)
137. DSC: The data science community (2016). URL <http://datasciencebe.com/>
138. DSCentral: Data science central (2016). URL <http://www.datasciencecentral.com/>
139. DSE: Data science and engineering (2015). URL <http://link.springer.com/journal/41019>
140. DSJ: Data science journal (2014). URL [www.datascience.codata.org](http://www.datascience.codata.org)
141. DSKD: Data science and knowledge discovery lab, university of technology Sydney (2007). URL <http://www.uts.edu.au/research-and-teaching/our-research/quantum-computation-and-intelligent-systems/data-sciences-and>
142. DSSG: Data science for social good fellowship. URL <https://dsdg.uchicago.edu/>
143. Duncan, D.E.: *Experimental Man: What One Man’s Body Reveals about His Future, Your Health, and Our Toxic World*. New York: Wiley & Sons (2009)
144. Dunleavy, P.: The social science of human-dominated & human-influenced systems: Annual lecture report (2014). URL <http://www.acss.org.uk/news/annual-lecture-report/>
145. van Dyk, D., Fuentes, M., Jordan, M.I., Newton, M., Ray, B.K., Lang, D.T., Wickham, H.: ASA statement on the role of statistics in data science (2015). URL <http://magazine.amstat.org/blog/2015/10/01/asa-statement-on-the-role-of-statistics-in-data-science/>
146. (Ed.), M.P.: *Similarity-based pattern analysis and recognition*. Springer (2013)
147. Edx: EDX courses (2016). URL [https://www.edx.org/course?search\\_query=data+science](https://www.edx.org/course?search_query=data+science)
148. Ehling, M., Korner, T.: *Handbook on Data Quality Assessment Methods and Tools* (eds.). EUROSTAT, Wiesbaden (2007)
149. Elder, L., Paul, R.: *The Thinker’s Guide to Analytic Thinking: How to Take Thinking Apart and What to Look for When You Do* (2nd ed.). Foundation for Critical Thinking (2007)
150. EMC: Data science revealed: A Data-Driven glimpse into the burgeoning new field (2011). URL [www.emc.com/collateral/about/news/emc-data-science-study-wp.pdf](http://www.emc.com/collateral/about/news/emc-data-science-study-wp.pdf)
151. EPJDS: EPJ data science (2012). URL <http://epjdatascience.springeropen.com/>
152. ESF: Research integrity : European science foundation (2016). URL [www.archives.esf.org/coordinating-research/mo-fora/research-integrity.html](http://www.archives.esf.org/coordinating-research/mo-fora/research-integrity.html)
153. ESRC: Big data and the social sciences: A perspective from the esrc. URL [https://www2.warwick.ac.uk/fac/soc/economics/research/centres/cage/events/conferences/peuk/peter\\_elias\\_big\\_data\\_and\\_the\\_social\\_sciences\\_pe\\_final.pdf](https://www2.warwick.ac.uk/fac/soc/economics/research/centres/cage/events/conferences/peuk/peter_elias_big_data_and_the_social_sciences_pe_final.pdf)
154. EU-DSA: The European data science academy (2016). URL [www.edsa-project.eu](http://www.edsa-project.eu)
155. EU-OD: The European union open data portal (2016). URL <https://open-data.europa.eu/>
156. Facebook: Facebook data (2016). URL <https://www.facebook.com/careers/teams/data/>

157. Faghmous, J.H., Kumar, V.: A big data guide to understanding climate change: The case for theory-guided data science. *Big Data* **2**(3), 155–163 (2014)
158. Fairfielda, J., Shteina, H.: Big data, big problems: Emerging issues in the ethics of data science and journalism. *Journal of Mass Media Ethics* **29**(1), 38–51 (2014)
159. Faris, J., Kolker, E., Szalay, A., Bradlow, L., Deelman, E., Feng, W., Qiu, J., Russell, D., Stewart, E., Kolker, E.: Communication and data-intensive science in the beginning of the 21st century. *A Journal of Integrative Biology* **15**(4), 213–215 (2011)
160. Fawcett, T.: Mining the quantified self: Personal knowledge discovery as a challenge for data science. *Big Data* **3**(4), 249–266 (2016)
161. Fayyad, U., Piatetsky-Shapiro, G., Smyth, P.: From data mining to knowledge discovery in databases. *AI Magazine* **17**(3), 37–54 (1996)
162. Feng, J.X., Kusiak, A.: Data mining applications in engineering design, manufacturing and logistics. *International Journal of Production Research* **44**(14), 2689–2694 (2007)
163. Fichman, P., Rosenbaum, H.: *Social Informatics: Past, Present and Future*. Cambridge Scholars Publishing (2014)
164. Finzer, W.: The data science education dilemma. *Technology Innovations in Statistics Education* **7**(2) (2013). URL <http://escholarship.org/uc/item/7gv0q9dc#page-1>
165. Floreano, D., Mattiussi, C.: *Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies*. The MIT Press (2008)
166. Floridi, L.: *The ethics of information*. Oxford University Press (2013)
167. Floridi, L., Taddeo, M.: What is data ethics. *Phil. Trans. R. Soc. A* **374**(2083) (2016)
168. Forbes: The world's biggest public companies (2016). URL <https://www.forbes.com/global2000/list>
169. Fox, G., Maini, S., Rosenbaum, H., Wild, D.J.: Data science and online education. In: 2015 IEEE 7th International Conference on Cloud Computing Technology and Science (CloudCom), pp. 582–587 (2015)
170. Freedman, D., Pisani, R., Purves, R.: *Statistics* (4th edn.). W. W. Norton (2007)
171. G. Szekely, e.a.: Measuring and testing independence by correlation of distances. *Annals of Statistics* **35**(6), 2769–2794 (2007)
172. Galetto, M.: Top 50 data science resources (2016). URL <http://www.ngdata.com/top-data-science-resources/>
173. Galin, D.: *Software Quality Assurance: From Theory to Implementation*. Pearson (2003)
174. Ganis, M., Kohirkar, A.: *Social Media Analytics: Techniques and Insights for Extracting Business Value Out of Social Media*. IBM Press (2015)
175. Ganiz, M., George, C., Pottenger, W.: Higher order naive bayes: A novel non-iid approach to text classification. *IEEE Transactions on Knowledge and Data Engineering* **23**(7), 1022–1034 (2011)
176. Gavrilovski, A., Jimenez, H., Mavris, D.N., Rao, A.H., Shin, S., Hwang, I., Marais, K.: Challenges and opportunities in flight data mining: A review of the state of the art. In: AIAA Infotech Aerospace, AIAA SciTech Forum, (AIAA 2016-0923), pp. 1–66 (2016)
177. Geczy, P.: Big data characteristics. *The Macrotheme Review* **3**(6), 94–104 (2014)
178. Gentle, J.E.: *Computational Statistics*. Springer Publishing Company (2009)
179. GEO: Gene expression omnibus (2016). URL <http://www.ncbi.nlm.nih.gov/geo/>
180. George, G., Osinga, E., Lavie, D., Scott, B.: Big data and data science methods for management research. *Academy of Management Journal* **59**(5), 1493–1507 (2016). URL [https://aom.org/uploadedFiles/Publications/AMJ/Oct\\_2016\\_FTE.pdf](https://aom.org/uploadedFiles/Publications/AMJ/Oct_2016_FTE.pdf)
181. Ghodke, D.: Bye bye 2015: What lies ahead for bi? (2015). URL [www.ciol.com/bye-bye-2015-what-lies-ahead-for-bi/](http://www.ciol.com/bye-bye-2015-what-lies-ahead-for-bi/)
182. Github: Data science colleges (2016). URL <https://github.com/ryanswanstrom/awesome-datascience-colleges>. (retrieved on 4 April 2016)
183. Github: List of recommender systems (2016). URL [https://github.com/grahamjenson/list\\_of\\_recommender\\_systems](https://github.com/grahamjenson/list_of_recommender_systems)
184. Gitub, D.: Data science for social good. URL <https://github.com/dssg>

185. Globalsecurity: Worldwide military command and control system (1996). URL <http://www.globalsecurity.org/wmd/systems/wwmccs.htm>
186. Gold, M., McClarren, R., Gaughan, C.: The lessons oscar taught us: Data science and media & entertainment. *Big Data* **1**(2), 105–109 (2013)
187. Golge, E.: Brief history of machine learning, a blog from a human-engineer-being. retrieved 21 march 2017 (2017). URL <http://www.erogol.com/brief-history-machine-learning/>
188. Goodfellow, I., Bengio, Y., Courville, A.: *Deep Learning*. MIT Press (2016). URL <http://www.deeplearningbook.org>
189. Google: Deepmind (2016). URL <https://deepmind.com/>
190. Google: Google bigquery and cloud platform (2016). URL <https://cloud.google.com/bigquery/>
191. Google: Google cloud prediction api (2016). URL <https://cloud.google.com/prediction/docs/>
192. Google: Google online open education (2016). URL <https://www.google.com/edu/openonline/>
193. Google: Google trends (2016). URL <https://www.google.com.au/trends/explore#q=data%20science%2C%20data%20analytics%2C%20big%20data%2C%20data%20analysis%2C%20advanced%20analytics&cmpt=q&tz=Etc%2FGMT-11>. Retrieved on 14 November 2016
194. Google: Open mobile data (2016). URL [https://console.developers.google.com/storage/browser/openmobiledata\\_public/](https://console.developers.google.com/storage/browser/openmobiledata_public/)
195. Government, B.M.: Beijing big data and cloud computing development action plan (2016). URL <http://zhengwu.beijing.gov.cn/gh/dt/t1445533.htm>
196. Government, C.: China big data (2015). URL [http://www.gov.cn/zhengce/content/2015-09/05/content\\_10137.htm](http://www.gov.cn/zhengce/content/2015-09/05/content_10137.htm)
197. Graham, M.J.: The art of data science. In: *Astrostatistics and Data Mining*, Volume 2 of the series Springer Series in Astrostatistics, pp. 47–59 (2012)
198. Gray, J.: *escience – a transformed scientific method* (2007). URL [http://research.microsoft.com/en-us/um/people/gray/talks/NRC-CSTB\\_eScience.ppt](http://research.microsoft.com/en-us/um/people/gray/talks/NRC-CSTB_eScience.ppt)
199. GTD: Global terrorism database (2016). URL <https://www.start.umd.edu/gtd/>
200. Gupta, A., Cecen, A., Goyal, S., Singh, A.K., Kalidindi, S.R.: Structure-property linkages using a data science approach: Application to a non-metallic inclusion/steel composite system. *Acta Mater* **91**, 239–254 (2015)
201. H. Lu, e.a.: Beyond intratransaction association analysis. *ACM Transactions on Information Systems* **18**(4), 423–454 (2000)
202. Han, J., Kamber, M., Pei, J.: *Data Mining: Concepts and Techniques*, 3rd edn. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA (2011)
203. Hand, D.J.: Statistics and computing: The genesis of data science. *Statistics and Computing* **25**(4), 705–711 (2015)
204. Hardin: Github (2016). URL [www.hardin47.github.io/DataSciStatsMaterials/](http://www.hardin47.github.io/DataSciStatsMaterials/)
205. Hardin, J., Hoerl, R., Horton, N.J., Nolan, D.: Data science in statistics curricula: Preparing students to “think with data”. *The American Statistician* **69**(4), 343–353 (2015)
206. Harris, H., Murphy, S., Vaisman, M.: *Analyzing the Analyzers: An Introspective Survey of Data Scientists and Their Work*. O’Reilly Media (2013)
207. Hastie, T., Tibshirani, R., Friedman, J.H.: *The elements of statistical learning: data mining, inference, and prediction*, 2nd Edition. Springer (2009)
208. Hazena, B.T., Booneb, C.A., Ezellc, J.D., Jones-Farmer, L.A.: Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications. *International Journal of Production Economics* **154**, 72–80 (2014)
209. Hey, T., Tansley, S., (Eds.), K.T.: *The Fourth Paradigm: Data-Intensive Scientific Discovery*. Microsoft Research (2009). URL <http://research.microsoft.com/en-us/collaboration/fourthparadigm/>
210. Hey, T., Trefethen, A.: *The Data Deluge: An e-Science Perspective*, pp. 809–824. John Wiley & Sons (2003)

211. HLSG: Final report of the high level expert group on scientific data. In: Riding the wave: How Europe can gain from the rising tide of scientific data (2010). URL [http://ec.europa.eu/information\\_society/newsroom/cf/document.cfm?action=display&doc\\_id=707](http://ec.europa.eu/information_society/newsroom/cf/document.cfm?action=display&doc_id=707)
212. HLSG: An rda europe report. In: The Data Harvest: How sharing research data can yield knowledge, jobs and growth (2014). URL [http://www.e-nformation.ro/wp-content/uploads/2014/12/TheDataHarvestReport\\_-Final.pdf](http://www.e-nformation.ro/wp-content/uploads/2014/12/TheDataHarvestReport_-Final.pdf)
213. Hofmann, T., Schölkopf, B., Smola, A.J.: Kernel methods in machine learning (2008)
214. Horizon: European commission horizon 2020 big data private public partnership (2014). URL <http://ec.europa.eu/programmes/horizon2020/en/h2020-section/information-and-communication-technologies>
215. Horton, N.J., Baumer, B.S., Wickham, H.: Setting the stage for data science: Integration of data management skills in introductory and second courses in statistics. arXiv preprint arXiv:1502.00318 (2015)
216. Huber, P.J.: Data Analysis: What Can Be Learned From the Past 50 Years. John Wiley & Sons (2011)
217. IASC: International association for statistical computing (1977). URL <http://www.iasc-isi.org/>
218. IBM: The value of analytics in healthcare. URL <https://www.ibm.com/services/us/gbs/thoughtleadership/ibv-healthcare-analytics.html>
219. IBM: Capitalizing on complexity (2010). URL <http://www-935.ibm.com/services/us/ceo/ceostudy2010/multimedia.html>
220. IBM: Ibm analytics and big data (2016). URL <http://www.ibm.com/analytics/us/en/> or <http://www-01.ibm.com/software/data/bigdata/>
221. IBM: Ibm watson (2016). URL <https://www.ibm.com/watson/>
222. IBM: What is a data scientist? (2016). URL <http://www-01.ibm.com/software/data/infosphere/data-scientist/>
223. IEEEED: IEEE big data initiative (2014). URL <http://bigdata.ieee.org/>
224. IEMSS: The international environmental modelling & software society. URL <http://www.iemss.org/society/>
225. IFSC-96: Data science, classification, and related methods. In: IFSC-96 (1996). URL <http://d-nb.info/955715512/04>
226. IJDS: International journal of data science (2016). URL <http://www.inderscience.com/jhome.php?jcode=ijds>
227. IJRDS: International journal of research on data science (2017). URL <http://www.sciencepublishinggroup.com/journal/index?journalid=310>
228. INFORMS: Informs code of ethics for certified analytics professionals. URL <https://www.certifiedanalytics.org/ethics.php>
229. INFORMS: Candidate handbook (2014). URL <https://www.informs.org/Certification-Continuing-Education/Analytics-Certification/Candidate-Handbook>
230. INFORMS: Institute for operations research and the management sciences (2016). URL <https://www.informs.org/>
231. Iwata, S.: Scientific “agenda” of data science. *Data Science Journal* 7(5), 54–56 (2008)
232. J. Hair, e.a.: *Multivariate data analysis* (7th Edition). Prentice Hall (2009)
233. Jagadish, H., Gehrke, J., Labrinidis, A., Papakonstantinou, Y., Patel, J.M., Ramakrishnan, R., Shahabi, C.: Big data and its technical challenges. *Communications of the ACM* 57(7), 86–94 (2014)
234. Jagadish, H.V.: Big data and science: Myths and reality. *Big Data Research* 2(2), 49–52 (2015)
235. JDS: *Journal of data science* (2002). URL <http://www.jds-online.com/>
236. JDSA: *International journal of data science and analytics* (JDSA) (2015). URL <http://www.springer.com/41060>
237. JFDS: *The journal of finance and data science* (2016). URL <http://www.keaipublishing.com/en/journals/the-journal-of-finance-and-data-science/>

238. Johnstone, I., Roberts, F.: Data science at nsf (2014). URL <http://www.nsf.gov/attachments/130849/public/Stodden-StatsNSF.pdf>
239. Jones, R.P.: Foundations of Critical Thinking. Cengage Learning (2000)
240. Josephson, R., J. & G. Josephson, S.: Abductive Inference: Computation, Philosophy, Technology. Cambridge University Press, New York & Cambridge (1994)
241. Kaggle: Kaggle competition data (2016). URL <https://www.kaggle.com/competitions>
242. Kalidindi, S.R.: Data science and cyberinfrastructure: critical enablers for accelerated development of hierarchical materials. *International Materials Reviews* **60**(3), 150–168 (2015)
243. Kan, S.H.: Metrics and Models in Software Quality Engineering, 2nd Edition. Addison-Wesley Professional (2002)
244. Kanter, J.M., Veeramachaneni, K.: Deep feature synthesis: Towards automating data science endeavors. In: 2015 IEEE International Conference on Data Science and Advanced Analytics (DSAA), pp. 1–10 (2015)
245. KDD89: IJCAI-89 workshop on knowledge discovery in databases (1989). URL <http://www.kdnuggets.com/meetings/kdd89/index.html>
246. KDNuggets: Visualization software (2015). URL <http://www.kdnuggets.com/software/visualization.html>
247. Kdnuggets: Kdnuggets (2016). URL <http://www.kdnuggets.com/>
248. KDNuggets: Software suites/platforms for analytics, data mining, & data science (2017). URL <http://www.kdnuggets.com/software/suites.html>
249. Keller, J.M., Liu, D., Fogel, D.B.: Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation. Wiley-IEEE Press (2016)
250. Kelly, K.: The quantified century. In: Quantified Self Conference (2012). URL <http://quantifiedself.com/conference/Palo-Alto-2012>
251. Kenett, R.S., Shmueli, G.: Information Quality: The Potential of Data and Analytics to Generate Knowledge. Wiley (2016)
252. Khan, N., Yaqoob, I., Hashem, I.A.T., et al: Big data: Survey, technologies, opportunities, and challenges. *The Scientific World Journal* **2014**, 18 (2014)
253. King, J., Magoulas, R.: 2015 data science salary survey (2015). URL <http://duu86o6n09pv.cloudfront.net/reports/2015-data-science-salary-survey.pdf>
254. Kirk, A.: Data Visualisation: A Handbook for Data Driven Design. SAGE Publications (2016)
255. Kirk, R.E.: Experimental Design: Procedures for the Behavioral Sciences (4th Edition). SAGE Publications (2012)
256. Kirkpatrick, K.: Putting the data science into journalism. *Communications of the ACM* **58**(5), 15–17 (2015)
257. Kohavi, R.: Mining e-commerce data: the good, the bad, and the ugly. In: SIGKDD, pp. 8–13 (2001)
258. Kohavi, R., Mason, L., Parekh, R., Zheng, Z.: Lessons and challenges from mining retail e-commerce data. *Mach. Learn.* **57**(1-2), 83–113 (2004)
259. Kohavi, R., Rothleder, N.J., Simoudis, E.: Emerging trends in business analytics. *Communications of the ACM* **45**(8), 45–48 (2002)
260. Koller, D., Friedman, N.: Probabilistic Graphical Models: Principles and Techniques. The MIT Press (2009)
261. Kramer, A., Guillory, J., Hancock, J.: Experimental evidence of massive-scale emotional contagion through social networks. *Proc. Natl. Acad. Sci.* **111**(24), 8788–8790 (2014)
262. Kung, S.Y.: Kernel Methods and Machine Learning. Cambridge University Press (2014)
263. Kurzweil, R.: How to Create a Mind: The Secret of Human Thought Revealed. Penguin Books (2013)
264. Lab, A.: Mlbase (2016). URL <http://mlbase.org/>
265. Labrinidis, A., Jagadish, H.V.: Challenges and opportunities with big data. *Proceedings of the VLDB Endowment* **5**(12), 2032–2033 (2012)
266. Laney, D.: 3D data management: Controlling data volume, velocity and variety (2001). Technical Report, META Group

267. Larder, B., Summerhayes, N.: Application of smiths aerospace data mining algorithms to british airways 777 and 747 fdm data (2004). URL [https://flightsafety.org/files/FDM\\_data\\_mining\\_report.pdf](https://flightsafety.org/files/FDM_data_mining_report.pdf)
268. Lassonde, M., Candel, S., Hacker, J., Quadrio-Curzio, A., Onishi, T., Ramakrishnan, V., McNutt, M.: G7 academies' joint statements 2017, new economic growth: The role of science, technology, innovation and infrastructure (2017)
269. Lazer, D., Kennedy, R., King, G., Vespignani, A.: The parable of google flu: Traps in big data analysis. *Science* **343**, 1203–1205 (2014)
270. LDC: Linguistic data consortium (2016). URL <https://www ldc.upenn.edu/about>
271. Lehmann, E.L., Lehmann, J.P.: *Testing Statistical Hypotheses*. Springer (2010)
272. Lencioni, P.: *The Five Dysfunctions of a Team: A Leadership Fable*. Jossey-Bass (2002)
273. Leonelli, S.: Locating ethics in data science: responsibility and accountability in global and distributed knowledge production systems. *Phil. Trans. R. Soc. A* **374** (2016)
274. Leuphana: Master's programme in management & data science (2017). URL <http://www.leuphana.de/en/graduate-school/master/course-offerings/management-data-science.html>
275. Li, R., Shengjie Wang, e.a.: Towards social user profiling: unified and discriminative influence model for inferring home locations. In: *Proceedings of KDD2012*, pp. 1023–1031 (2012)
276. LinkedIn: LinkedIn jobs (2016). URL <https://www.linkedin.com/jobs/data-scientist-jobs>
277. Loshin, D.: *Enterprise Knowledge Management*. Morgan Kaufmann (2001)
278. Loukides, M.: *The Evolution of Data Products*. O'Reilly, Cambridge (2011)
279. Loukides, M.: What is data science? O'Reilly Media, Sebastopol, CA (2012). URL <http://radar.oreilly.com/2010/06/what-is-data-science.html#data-scientists>
280. MacKay, D.J.C.: *Information Theory, Inference & Learning Algorithms*. Cambridge University Press, New York (2002)
281. Manieri, A., Brewer, S., Riestra, R., Demchenko, Y., Hemmje, M., Wiktorski, T., Ferrari, T., Frey, J.: Data science professional uncovered: How the EDISON project will contribute to a widely accepted profile for data scientists. In: *2015 IEEE 7th International Conference on Cloud Computing Technology and Science (CloudCom)*, pp. 588–593 (2015)
282. Manieri, A., Nucci, F.S., Femminella, M., Reali, G.: Teaching Domain-Driven data science: Public-Private co-creation of Market-Driven certificate. In: *2015 IEEE 7th International Conference on Cloud Computing Technology and Science (CloudCom)*, pp. 569–574 (2015)
283. Matsudaira, K.: The science of managing data science. *Communications of the ACM* **58**(6), 44–47 (2015)
284. Mattison, R.: *Data warehousing and data mining for telecommunications*. Artech House (1997)
285. Mattmann, C.A.: Computing: A vision for data science. *Nature* **493**(7433), 473–475 (2013)
286. Mattmann, C.A.: Cultivating a research agenda for data science. *Journal of Big Data* **1**(1), 1–8 (2014)
287. McCartney, P.R.: Big data science. *The American Journal of Maternal/Child Nursing* **40**(2), 130–130 (2015)
288. McKinsey: Big data: The next frontier for innovation, competition, and productivity (2011). McKinsey Global Institute
289. Microsoft: Azure. URL [www.azure.microsoft.com/](http://www.azure.microsoft.com/)
290. Miller, C.C.: Data science: The numbers of our lives. *New York Times* (2013). URL [http://www.nytimes.com/2013/04/14/education/edlife/universities-offer-courses-in-a-hot-new-field-data-science.html?pagewanted=all&\\_r=0](http://www.nytimes.com/2013/04/14/education/edlife/universities-offer-courses-in-a-hot-new-field-data-science.html?pagewanted=all&_r=0)
291. Miller, K., Taddeo, M.: The ethics of information technologies. In: *Library of Essays on the Ethics of Emerging Technologies* (ed.). NY: Routledge (2017)
292. MIT: Data analytics in urban transportation. URL <http://dusp.mit.edu/transportation/project/data-analytics-urban-transportation>
293. MIT: Checklist for software quality (2011). URL <http://web.mit.edu/~6.170/www/quality.html>
294. Mitchell, M.: *Complexity: A Guided Tour*. Oxford University Press (2011)
295. Mitchell, T.: *Machine Learning*. McGraw Hill (1997)

296. Mittelstadt, B., Floridi, L.: The ethics of big data: current and foreseeable issues in biomedical contexts. *Sci. Eng. Ethics* **22**, 303–341 (2015)
297. de Moraes, R.M., Martinez, L.: Computational intelligence applications for data science. *Knowledge-Based Systems* **87**, 1–2 (2015)
298. Morrell, A.J.H.: Information processing 68 (ed.). In: *Proceedings of IFIP Congress 1968*. Edinburgh, UK (1968)
299. Murray-Rust, P.: Data-Driven science: A scientist’s view. In: *NSF/JISC 2007 Digital Repositories Workshop (2007)*. URL <http://www.sis.pitt.edu/repwkshop/papers/murray.pdf>
300. Naur, P.: ‘datalogy’, the science of data and data processes. In: *Proceedings of the IFIP Congress 68*, pp. 1383–1387 (1968)
301. Naur, P.: *Concise Survey of Computer Methods*. Studentlitteratur, Lund, Sweden (1974)
302. NCSU: Institute for advanced analytics, north carolina state university (2007). URL <http://analytics.ncsu.edu/>
303. NCSU: Master of science in analytics, institute for advanced analytics, north carolina state university (2007). URL <http://analytics.ncsu.edu/>
304. Neapolitan, R.E.: *Learning Bayesian Networks*. Prentice-Hall, Upper Saddle River, NJ, USA (2003)
305. Nelson, M.L.: Data-driven science: A new paradigm? *EDUCAUSE Review* **44**(4), 6–7 (2009)
306. von Neumann, J., Kurzweil, R.: *The Computer and the Brain*, 3rd Edition. Yale University Press (2012)
307. Neville, J., Jensen, D.: Relational dependency networks. *The Journal of Machine Learning Research* **8**, 653–692 (2007)
308. NICTA: National ict Australia (2016). URL <https://www.nicta.com.au/>
309. NIST: NIST text retrieval conference data (2015). URL <http://trec.nist.gov/data.html>
310. NSB: Long-lived digital data collections: Enabling research and education in the 21st century. In: *US National Science Board (2005)*. URL <http://www.nsf.gov/pubs/2005/nsb0540/>
311. NSF: US NSF07-28. In: *Cyberinfrastructure Vision for 21st Century Discovery (2007)*. URL <http://www.nsf.gov/pubs/2007/nsf0728/nsf0728.pdf>
312. OECD: OECD principles and guidances for access to research data from public funding (2007). URL <https://www.oecd.org/sti/sci-tech/38500813.pdf>
313. OECD: Data-driven innovation: Big data for growth and well-being (2015). doi:<http://dx.doi.org/10.1787/9789264229358-en>
314. OECD: The next production revolution: Implications for governments and business (2017). doi:<http://dx.doi.org/10.1787/9789264271036-en>
315. O’Leary, D.E.: Ethics for big data and analytics. *IEEE Intelligent Systems* **31**(4), 81–84 (2016)
316. O’Neil, C., Schutt, R.: *Doing data science: Straight talk from the frontline*. O’Reilly Media, Sebastopol, CA (2013)
317. OpenCV: Open source computer vision library (2016). URL [www.opencv.org/](http://www.opencv.org/)
318. OPENedX: OPENedX online education platform (2016). URL <https://open.edx.org/>
319. O’Reilly, T.: *What is web 2.0 (2005)*. URL <http://oreilly.com/pub/a/web2/archive/what-is-web-20.html?page=3>
320. Pal, S.K., Meher, S.K., Skowron, A.: Data science, big data and granular mining. *Pattern Recognition Letters* **67**(2), 109–112 (2015)
321. Pan, S.J., Yang, Q.: A survey on transfer learning. *IEEE Trans. on Knowl. and Data Eng.* **22**(10), 1345–1359 (2010)
322. Patil, D.: *Building Data Science Teams*. O’Reilly Media (2011)
323. Patterson, K., Grenny, J.: *Crucial Conversations Tools for Talking When Stakes Are High (Second Edition)*. McGraw-Hill Education (2011)
324. Paul, R., Elder, L.: *The Thinker’s Guide to Scientific Thinking Based on Critical Thinking Concepts & Principles*. Foundation for Critical Thinking (2008)
325. Paulk, M.C., Curtis, B., Chrissis, M.B., Weber, C.V.: Capability maturity model version 1.1. *IEEE Software* **10**(4), 18–27 (1993)

326. Pearson, K.: Report on certain enteric fever inoculation statistics. *Br Med J.* **2**(2288), 1243–1246 (1904)
327. Peter, F., James, H.: The science of data science. *Big Data* **2**(2), 68–70 (2014)
328. Philip, J.C.: *Computer Generated Artificial Life: A Biblical And Logical Analysis (Integrated Apologetics)*, 10th edition. Philip Communications (2015)
329. Pike, J.: *Global command and control system* (2003). URL <https://fas.org/nuke/guide/usa/c3i/gccs.htm>
330. Press, G.: A very short history of data science (2013). URL <http://www.forbes.com/sites/gilpress/2013/05/28/a-very-short-history-of-data-science/#61ae3ebb69fd>
331. Priebe, T., Markus, S.: Business information modeling: A methodology for data-intensive projects, data science and big data governance. In: 2015 IEEE International Conference on Big Data (Big Data), pp. 2056–2065 (2015)
332. Provost, F., Fawcett, T.: Data science and its relationship to big data and Data-Driven decision making. *Big Data* **1**(1), 51–59 (2013)
333. Qian, X.: Revisiting issues on open complex giant systems. *Pattern Recognit. Artif. Intell.* **4**(1), 5–8 (1991)
334. Qian, X.: *Building Systematism*. ShanXi Sci. Technol Press, Taiyuan, China (2001)
335. Qian, X., Yu, J., Dai, R.: A new discipline of science—the study of open complex giant system and its methodology. *Chin. J. Syst. Eng. Electron.* **4**(2), 2–12 (1993)
336. Raghavan, S.N.: Data mining in e-commerce: A survey. *Sadhana* **30**(2 & 3), 275–289 (2005)
337. RapidMiner: *Rapidminer* (2016). URL <https://rapidminer.com/>
338. Redman, T.: *Data Quality: The Field Guide*. Digital Press (2001)
339. Renae, S.: *Data analytics: Crunching the future*. Bloomberg Businessweek (2011). September 8
340. Review, S.: *Data integration and application integration solutions directory* (2016). URL <http://solutionsreview.com/data-integration/data-integration-solutions-directory/>
341. Rifkin, J.: *The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World*. Palgrave MacMillan (2011)
342. Rowley, J.: The wisdom hierarchy: representations of the DIKW hierarchy. *Journal of Information and Communication Science* **33**(2), 163–180 (2007)
343. Rudin, C., Dunson, D., Irizarry, R., Ji, H., Laber, E., Leek, J., McCormick, T., Rose, S., Schafer, C., van der Laan, M., Wasserman, L., Xue, L.: *Discovery with data: Leveraging statistics with computer science to transform science and society* (2014). URL <http://www.amstat.org/policy/pdfs/BigDataStatisticsJune2014.pdf>. A Working Group of the American Statistical Association
344. Russell, S.J., Norvig, P.: *Artificial Intelligence: A Modern Approach*, 2 edn. Pearson Education (2003)
345. SAS: *Big data analytics: An assessment of demand for labour and skills, 2012-2017* (2013). URL [https://www.thetechpartnership.com/globalassets/pdfs/research-2014/bigdata\\_report\\_nov14.pdf](https://www.thetechpartnership.com/globalassets/pdfs/research-2014/bigdata_report_nov14.pdf). Report. SAS/The Tech Partnership
346. SAS: *Sas enterprise miner* (2016). URL <http://www.sas.com>
347. SAS: *SAS insights* (2016). URL [http://www.sas.com/en\\_us/insights.html](http://www.sas.com/en_us/insights.html)
348. Sayama, H.: *Introduction to the Modeling and Analysis of Complex Systems*. Open SUNY Textbooks (2015)
349. Schadt, E., Chilukuri, S.: *The role of big data in medicine* (2015). URL <http://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/the-role-of-big-data-in-medicine>
350. Schoenherr, T., Speier-Pero, C.: Data science, predictive analytics, and big data in supply chain management: Current state and future potential. *Journal of Business Logistics* **36**(1), 120–132 (2015)
351. Schulmeyer, G.G., Mcmanus, J.I.: *Handbook of Software Quality Assurance*, 3rd Edition. Prentice Hall PTR (1998)
352. SCJ: *Science council of Japan - code of conduct for scientists* (2017). URL [www.scj.go.jp/en/report/code.html](http://www.scj.go.jp/en/report/code.html)

353. Scott, J.: *Social Network Analysis* (4th Edition). SAGE Publications (2017)
354. SDS: Social data science lab. URL <http://socialdatalab.net/>
355. Sebastian-Coleman, L.: *Measuring Data Quality for Ongoing Improvement: A Data Quality Assessment Framework*. Morgan Kaufmann (2013)
356. Security, C.L.: Big data strategies and actions in major countries (2015). URL [http://www.cac.gov.cn/2015-07/03/c\\_1115812491.htm](http://www.cac.gov.cn/2015-07/03/c_1115812491.htm)
357. Shi, C., Yu, P.S.: *Heterogeneous Information Network Analysis and Applications*. Springer (2017)
358. SIAM: Siam career center (2016). URL <http://jobs.siam.org/home/>
359. Siart, C., Kopp, S., Apel, J.: The interface between data science, research assessment and science support - highlights from the German perspective and examples from Heidelberg university. In: 2015 IIAI 4th International Congress on Advanced Applied Informatics (IIAI-AAI), pp. 472–476 (2015)
360. Silk: Data science university programs (2016). URL <http://data-science-university-programs.silk.co/>
361. Simovici, D.A., Djeraba, C.: *Mathematical Tools for Data Mining: Set Theory, Partial Orders, Combinatorics*. Springer Publishing Company (2008)
362. Siroker, D., Koomen, P.: *A / B Testing: The Most Powerful Way to Turn Clicks Into Customers*. Wiley (2015)
363. Smarr, L.: Quantifying your body: A how-to guide from a systems biology perspective. *Biotechnology Journal* **7**(8), 980–991 (2012). doi:10.1002/biot.201100495. URL <http://dx.doi.org/10.1002/biot.201100495>
364. Smith, F.J.: Data science as an academic discipline. *Data Science Journal* **5**, 163–164 (2006)
365. SMU: Living analytics research centre (2017). URL <https://larc.smu.edu.sg/>
366. Sobel, C., Li, P.: *The Cognitive Sciences: An Interdisciplinary Approach* (2nd Edition). SAGE Publications (2013)
367. Society, B.R.A.: Astronomical databases and archives. URL <https://www.ras.org.uk/education-and-careers/for-everyone/126-astronomical-databases-and-archives>
368. Sonnenburg, S., Raetsch, G.: *Shogun* (2016). URL <http://www.shogun-toolbox.org/>
369. SSDS: Springer series in the data sciences (2015). URL <http://www.springer.com/series/13852>
370. Stanford: Stanford data science initiatives, Stanford university (2014). URL <https://sdsi.stanford.edu/>
371. Stanton, J.: An introduction to data science (2012). URL <http://surface.syr.edu/istpub/165/>
372. Stevens, M.L.: An ethically ambitious higher education data science. *Research & Practice in Assessment* **9**, 96–97 (2014)
373. Stewart, T.R., McMillan, J.C.: Descriptive and prescriptive models for judgment and decision making: Implications for knowledge engineering. In: J.L. Mumpower, O. Renn, L.D. Phillips, V.R.R.U. (Eds.) (eds.) *Expert Judgment and Expert Systems*, pp. 305–320. Springer-Verlag, London (1987)
374. Stonebraker, M., Madden, S., Dubey, P.: Intel ‘big data’ science and technology center vision and execution plan. *SIGMOD Record* **42**(1), 44–49 (2013)
375. Suchma, L.: *Human-Machine Reconfigurations: Plans and Situated Actions*. Cambridge University Press (2006)
376. Swan, A., Brown, S.: The skills, role & career structure of data scientists & curators: Assessment of current practice & future needs. In: UK Joint Information Systems Committee (2008). Technical Report. University of Southampton
377. Swan, M.: The quantified self: Fundamental disruption in big data science and biological discovery. *Big Data* **1**(2), 85–99 (2013)
378. Taddeo, M., (eds.), L.F.: The ethical impact of data science. *Phil. Trans. R. Soc. A* **374** (2016). URL <http://rsta.royalsocietypublishing.org/content/374/2083>
379. Taleb, N.N.: *The Black Swan: The Impact of the Highly Improbable*. Random House, New York (2007)

380. Tang, L., Liu, H.: Community Detection and Mining in Social Media. Morgan and Claypool (2010)
381. Technavio: Top 10 healthcare data analytics companies (2016). URL <http://www.technavio.com/blog/top-10-healthcare-data-analytics-companies>
382. TFDSAA: IEEE task force on data science and advanced analytics (2013). URL <http://dsaaft.dsaac.co/>
383. Thrun, S., Pratt, L.e.: Learning to learn. Boston, Mass.: Kluwer Academic (1998)
384. Tilburg: Msc specialization data science: Business and governance (2017). URL <https://www.tilburguniversity.edu/education/masters-programmes/data-science-business-and-governance/>
385. TOBD: IEEE transactions on big data (2015). URL <https://www.computer.org/web/tbd>
386. Today, P.A.: 29 data preparation tools and platforms (2016). URL <http://www.predictiveanalyticstoday.com/data-preparation-tools-and-platforms/>
387. Tukey, J.W.: The future of data analysis. *Ann. Math. Statist.* **33**(1), 1–67 (1962)
388. Tukey, J.W.: *Exploratory Data Analysis*. Pearson (1977)
389. Tutiempo: Global climate data (2016). URL <http://en.tutiempo.net/climate>
390. U-Waikato: Weka (2016). URL <http://www.cs.ubc.ca/labs/beta/Projects/autoweka/>
391. UCI: UCI machine learning repository (2016). URL [www.archive.ics.uci.edu/ml/](http://www.archive.ics.uci.edu/ml/)
392. UCL: Msin105p: Critical analytical thinking (2015). URL <https://www.mgmt.ucl.ac.uk/module/msin105p-critical-analytical-thinking>
393. Udacity: Udacity courses (2016). URL <https://www.udacity.com/courses/data-science>
394. Udemey: Udemey courses (2016). URL <https://www.udemy.com/courses/search/?ref=home&\src=ukw&q=data+science&lang=en>
395. UK: Uk big data (2016). URL <https://www.ukri.org>
396. UK-HM: Uk hm government. In: *Open Data White Paper: Unleashing the Potential* (2012). URL [http://data.gov.uk/sites/default/files/Open\\_data\\_White\\_Paper.pdf](http://data.gov.uk/sites/default/files/Open_data_White_Paper.pdf)
397. UK-OD: UK open data (2016). URL <http://data.gov.uk/>
398. UMichi: Michigan institute for data science, university of Michigan (2015). URL <http://midas.umich.edu/>
399. UN: United nation global pulse projects (2010). URL <http://www.unglobalpulse.org/>
400. Uprichard, E.: Big data, little questions? (2013). URL <http://discoversociety.org/2013/10/01/focus-big-data-little-questions/>
401. US National Science Foundation: Critical techniques and technologies for advancing foundations and applications of big data science & engineering (bigdata) (2015). URL [https://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=504767](https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504767)
402. US National Science Foundation: Computational and data-enabled science and engineering (cde) (2017). URL [https://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=504813&org=CISE&sel\\_org=CISE&from=fund](https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504813&org=CISE&sel_org=CISE&from=fund)
403. US-OD: US government open data (2016). URL <https://www.data.gov/>
404. USAID: Usaid recommended data quality assessment (dqa) checklist (2016). URL <https://usaideallearninglab.org/sites/default/files/resource/files/201sae.pdf>
405. USD2D: US national consortium for data science (2016). URL [www.data2discovery.org](http://www.data2discovery.org)
406. USDSC: US degree programs in analytics and data science (2016). URL [http://analytics.ncsu.edu/?page\\_id=4184](http://analytics.ncsu.edu/?page_id=4184)
407. USNSF: US big data research initiative (2012). URL <http://www.nsf.gov/cise/news/bigdata.jsp>
408. UTS: Master of analytics (research) and doctor of philosophy thesis: Analytics, Advanced Analytics Institute, University of Technology Sydney (2011). URL <http://www.uts.edu.au/research-and-teaching-our-research/advanced-analytics-institute/education-and-research-opportuniti-1>
409. UTSAAI: Advanced analytics institute, university of technology Sydney (2011). URL <https://analytics.uts.edu.au/>
410. Vapnik, V.N.: *The Nature of Statistical Learning Theory*. Springer-Verlag New York, New York, USA (2000)

411. Vast: Visual analytics community (2016). URL <http://vacommunity.org/HomePage>
412. Veaux, R.D.D., Agarwal, M., Averett, M., Baumer, B.S., Bray, A., Bressoud, T.C., Bryant, L., Cheng, L.Z., Francis, A., Gould, R., Kim, A.Y., Kretchmar, M., Lu, Q., Moskol, A., Nolan, D., Pelayo, R., Raleigh, S., Sethi, R.J., Sondjaja, M., Tiruvilumala, N., Uhlig, P.X., Washington, T.M., Wesley, C.L., White, D., Ye, P.: Curriculum guidelines for undergraduate programs in data science. *Annu. Rev. Stat. Appl.* **4**(2), 1–16 (2017). URL <https://www.amstat.org/asa/files/pdfs/EDU-DataScienceGuidelines.pdf>
413. Vesset, D., Woo, B., Morris, H.D., Villars, R.L., Little, G., Bozman, J.S., Borovick, L., Olofson, C.W., Feldman, S., Conway, S., Eastwood, M., Yezhkova, N.: Worldwide big data technology and services 2012–2015 forecast (2012). IDC
414. Viseu, A., Suchman, L.: *Wearable Augmentations: Imaginaries of the Informed Body*, pp. 161–184. Berghahn Books, New York (2010)
415. Walker, M.A.: The professionalisation of data science. *Int. J. of Data Science* **1**(1), 7–16 (2015)
416. Wang, C., Cao, L., Chi, C.: Formalization and verification of group behavior interactions. *IEEE Trans. Systems, Man, and Cybernetics: Systems* **45**(8), 1109–1124 (2015)
417. WEF: *The global competitiveness report 2011–2012: An initiative of the world economic forum* (2011)
418. Wei, W.: *Copula-based high dimensional dependence modelling*. Ph.D. thesis, University of Technology Sydney (2014)
419. Wei Wei Junfu Yin, J.L., Cao, L.: Modeling asymmetry and tail dependence among multiple variables by using partial regular vine. In: *SDM2014* (2014)
420. Weiss, K., Khoshgoftaar, T.M., Wang, D.: A survey of transfer learning. *Journal of Big Data* **3**(1) (2016)
421. Whitehouse: The white house names dr. DJ patil as the first U.S. chief data scientist (2015). URL <https://www.whitehouse.gov/blog/2015/02/18/white-house-names-dr-dj-patil-first-us-chief-data-scientist>
422. Wikipedia: Bioinformatics. URL <https://en.wikipedia.org/wiki/Bioinformatics>
423. Wikipedia: Computational trust. URL [https://en.wikipedia.org/wiki/Computational\\_trust](https://en.wikipedia.org/wiki/Computational_trust)
424. Wikipedia: Computing. URL <https://en.wikipedia.org/wiki/Computing>
425. Wikipedia: Dikw pyramid. URL [https://en.wikipedia.org/wiki/DIKW\\_Pyramid](https://en.wikipedia.org/wiki/DIKW_Pyramid)
426. Wikipedia: Genetic linkage. URL [https://en.wikipedia.org/wiki/Genetic\\_linkage](https://en.wikipedia.org/wiki/Genetic_linkage)
427. Wikipedia: Health care & analytics. URL <http://analytics-magazine.org/health-care-analytics/>
428. Wikipedia: Intelligent transportation system. URL [https://en.wikipedia.org/wiki/Intelligent\\_transportation\\_system](https://en.wikipedia.org/wiki/Intelligent_transportation_system)
429. Wikipedia: Social influence. URL [https://en.wikipedia.org/wiki/Social\\_influence](https://en.wikipedia.org/wiki/Social_influence)
430. Wikipedia: Social network analysis. URL [https://en.wikipedia.org/wiki/Social\\_network\\_analysis](https://en.wikipedia.org/wiki/Social_network_analysis)
431. Wikipedia: Statistical relational learning. URL [https://en.wikipedia.org/wiki/Statistical\\_relational\\_learning](https://en.wikipedia.org/wiki/Statistical_relational_learning)
432. Wikipedia: Sustainability. URL <https://en.wikipedia.org/wiki/Sustainability>
433. Wikipedia: Targeted advertising. URL [https://en.wikipedia.org/wiki/Targeted\\_advertising](https://en.wikipedia.org/wiki/Targeted_advertising)
434. Wikipedia: Comparison of cluster software (2016). URL [https://en.wikipedia.org/wiki/Comparison\\_of\\_cluster\\_software](https://en.wikipedia.org/wiki/Comparison_of_cluster_software)
435. Wikipedia: General data protection regulation (2016). URL [https://en.wikipedia.org/wiki/General\\_Data\\_Protection\\_Regulation](https://en.wikipedia.org/wiki/General_Data_Protection_Regulation)
436. Wikipedia: Informatics (2016). URL <https://en.wikipedia.org/wiki/Informatics>
437. Wikipedia: List of reporting software (2016). URL [https://en.wikipedia.org/wiki/List\\_of\\_reporting\\_software](https://en.wikipedia.org/wiki/List_of_reporting_software)
438. Wikipedia: National data protection authority (2016). URL [https://en.wikipedia.org/wiki/National\\_data\\_protection\\_authority](https://en.wikipedia.org/wiki/National_data_protection_authority)
439. Wikipedia: Sports analytics (2016). URL [https://en.wikipedia.org/wiki/Sports\\_analytics](https://en.wikipedia.org/wiki/Sports_analytics)
440. Wikipedia: Accuracy, precision, recall and specificity (2017). URL [https://en.wikipedia.org/wiki/Precision\\_and\\_recall](https://en.wikipedia.org/wiki/Precision_and_recall)

441. Wikipedia: Capability maturity model (cmm) (2017). URL [https://en.wikipedia.org/wiki/Capability\\_Maturity\\_Model](https://en.wikipedia.org/wiki/Capability_Maturity_Model)
442. Wikipedia: Complexity (2017). URL <https://en.wikipedia.org/wiki/Complexity>
443. Wikipedia: Data quality (2017). URL [https://en.wikipedia.org/wiki/Data\\_quality](https://en.wikipedia.org/wiki/Data_quality)
444. Wikipedia: Industrial revolution (2017). URL [https://en.wikipedia.org/wiki/Industrial\\_Revolution](https://en.wikipedia.org/wiki/Industrial_Revolution)
445. Wikipedia: List of statistical packages (2017). URL [https://en.wikipedia.org/wiki/List\\_of\\_statistical\\_packages](https://en.wikipedia.org/wiki/List_of_statistical_packages)
446. Wikipedia: Second industrial revolution (2017). URL [https://en.wikipedia.org/wiki/Second\\_Industrial\\_Revolution](https://en.wikipedia.org/wiki/Second_Industrial_Revolution)
447. Wikipedia: Timeline of machine learning. retrieved 21 march 2017 (2017). URL [https://en.wikipedia.org/wiki/Timeline\\_of\\_machine\\_learning](https://en.wikipedia.org/wiki/Timeline_of_machine_learning)
448. Wikipedia: Agile software development (2018). URL [https://en.wikipedia.org/wiki/Agile\\_software\\_development](https://en.wikipedia.org/wiki/Agile_software_development)
449. Wikipedia: Industry 4.0 (2018). URL [https://en.wikipedia.org/wiki/Industry\\_4.0](https://en.wikipedia.org/wiki/Industry_4.0)
450. Wikipedia: Internet of things (2018). URL [https://en.wikipedia.org/wiki/Internet\\_of\\_things](https://en.wikipedia.org/wiki/Internet_of_things)
451. Wikipedia: Open access (2018). URL [https://en.wikipedia.org/wiki/Open\\_access](https://en.wikipedia.org/wiki/Open_access)
452. Wikipedia: Open data (2018). URL [https://en.wikipedia.org/wiki/Open\\_data](https://en.wikipedia.org/wiki/Open_data)
453. Wikipedia: Open education (2018). URL [https://en.wikipedia.org/wiki/Open\\_education](https://en.wikipedia.org/wiki/Open_education)
454. Wikipedia: Open peer review (2018). URL [https://en.wikipedia.org/wiki/Open\\_peer\\_review](https://en.wikipedia.org/wiki/Open_peer_review)
455. Wikipedia: Open science (2018). URL [https://en.wikipedia.org/wiki/Open\\_science](https://en.wikipedia.org/wiki/Open_science)
456. Wikipedia: Open source (2018). URL [https://en.wikipedia.org/wiki/Open\\_source\\_software](https://en.wikipedia.org/wiki/Open_source_software)
457. Wikipedia: Smart manufacturing (2018). URL [https://en.wikipedia.org/wiki/Smart\\_manufacturing](https://en.wikipedia.org/wiki/Smart_manufacturing)
458. Wikipedia: Waterfall model (2018). URL [https://en.wikipedia.org/wiki/Waterfall\\_model](https://en.wikipedia.org/wiki/Waterfall_model)
459. Williamson, J.: Big data analytics is transforming manufacturing (2016). URL <http://www.themanufacturer.com/articles/big-data-analytics-is-transforming-manufacturing/>
460. WIRED: How europe can seize the starring role in big data (2014). URL [www.wired.com/insights/2014/09/europe-big-data/](http://www.wired.com/insights/2014/09/europe-big-data/)
461. Wladawsky-Berger, I.: Why do we need data science when we've had statistics for centuries? The Wall Street Journal (2014). URL <http://blogs.wsj.com/cio/2014/05/02/why-do-we-need-data-science-when-weve-had-statistics-for-centuries/>
462. Wolf, G.: The data-driven life. New York Times (2012). URL [www.nytimes.com/2010/05/02/magazine/02self-measurement-t.html](http://www.nytimes.com/2010/05/02/magazine/02self-measurement-t.html)
463. Woodall P., B.A., Parlikad, A.: Data quality assessment: The hybrid approach. *Information & Management* **50**(7), 369–382 (2013)
464. Woodall P., O.M., A., B.: A classification of data quality assessment and improvement methods. *International Journal of Information Quality* **3**(4), 298–321 (2014)
465. Works, B.: Burtch works flash survey (2014). URL <http://www.burtchworks.com/category/flash-survey/>
466. WTTC: Big data - the impact on travel & tourism (2014). URL <https://www.wttc.org/research/other-research/big-data-the-impact-on-travel-tourism/>
467. Wu, J.: Statistics = data science? (1997). URL <http://www2.isye.gatech.edu/~jeffwu/presentations/datascience.pdf>
468. Xie, T., Thummalapenta, S., Lo, D., Liu, C.: Data mining for software engineering. *Computer* **42**(8) (2009)
469. Yahoo: Yahoo finance (2016). URL [www.finance.yahoo.com](http://www.finance.yahoo.com)
470. Yau, N.: Rise of the data scientist (2009). URL <http://flowingdata.com/2009/06/04/rise-of-the-data-scientist/>
471. Yin, J., Zheng, Z., Cao, L.: Uspan: An efficient algorithm for mining high utility sequential patterns. In: *KDD 2012*, pp. 660–668 (2012)
472. Yiu, C.: The big data opportunity (2012). URL <http://www.policyexchange.org.uk/images/publications/the%20big%20data%20opportunity.pdf>
473. Yu, B.: IMS presidential address: Let us own data science. *IMS Bulletin Online* (2014). 1 Oct 2014

# Index

## A

- abductive inference, 63
- abductive reasoning, 63
- A/B testing, 83
- actionability, 87, 145, 213
- actionable data science, 198
- actionable insights, 127
- actionable knowledge, 213
- actionable knowledge discovery, 213
- actionability, 41
- advanced AI, 247
- advanced analytics, 5, 36
- advanced techniques, 210
- agent intelligence, 159
- agent mining, 159
- agile methodology, 266
- algebra, 205
- AlphaGo, 55, 112
- AlphaGo zero, 55
- American data initiatives, 25
- American Statistics Association (ASA), 34
- analysis, 168
- analysis and processing, 168, 171
- analytical insight, 43
- analytics misconceptions, 53
- analytics reliability, 114
- analytics validity, 114
- analytics variability, 114
- analytics veracity, 114
- animated intelligence, 102
- anybody quantification, 30
- anyform quantification, 30
- anyplace quantification, 30
- anysource quantification, 30
- anyspeed quantification, 30
- anytime quantification, 30
- Apache Ambari, 217
- Apache HBase, 217
- Apache Hive, 217
- Apache Oozie, 217
- Apache Pig, 217
- Apache Spark, 217
- Apache Sqoop, 217
- Apache Storm, 217
- Apache Zookeeper, 217
- application integration tools, 325
- application scenarios, 264
- arc, 211
- artificial intelligence, 110, 214
- artificial life system, 113
- assisting techniques, 214
- association discovery, 209
- association rule mining, 209
- assurance layer, 76
- Australian data initiatives, 23
- authority, 61
- autonomous analytical systems, 158
- autonomous analytics, 158
- autonomous data modeling, 158
- autonomous data modeling agents, 158
- autonomous data modeling multi-agent systems, 159
- autonomous data systems, 159
- autonomous learning agents, 158
- autonomous learning systems, 158
- autonomy, 48

**B**

Bachelor in data science, 339  
 Bayesian belief network, 211  
 Bayesian network, 211  
 behavior, 16, 33, 100, 150  
 behavior complexity, 18, 95  
 behavior computing, 100  
 behavior construction, 150  
 behavior informatics, 100, 151  
 behavior insight, 150  
 behavior intelligence, 19, 100  
 behavior model, 151  
 behavior modeling, 151  
 behavior representation, 151  
 behavior world, 150  
 behavior, entity, relationship and property, 33  
 behavioral data, 150  
 belief, 211  
 belief network, 211  
 BERP, 33  
 beyond IID, 80  
 BI professionals, 319  
 big data, 3, 5, 144, 216  
 big data analytics, 114  
 big data era, 29  
 big data landscape, 237  
 big data research initiative, 25  
 big data strategy, 23  
 big data technologies, 216  
 bio-inspired computing, 84  
 bitcoin, 355  
 blind knowledge space, 104  
 body of knowledge, 332  
 boosting, 145  
 bottom-up reductionism, 71  
 brain science, 163  
 built-in algorithms, 226  
 business analyst, 327  
 business behavioral strategist, 327  
 business intelligence, 319  
 business intelligence reporting tools, 326  
 business values, 310

**C**

capability goal satisfaction, 311  
 capability immaturity, 103  
 capability maturity, 308, 311  
 capability maturity model, 308  
 capability power, 311  
 capability usability, 311  
 capability value potential, 311  
 capability-data fitness, 311  
 carbon nanotube transistors, 356

causality, 145  
 chief analytics officer, 314  
 Chief Data Officer, 314  
 Chief Data Scientist, 314  
 Chinese data initiatives, 24  
 classic IT businesses, 240  
 classic techniques, 208  
 closed environment, 103  
 closed problems, 70  
 cloud computing, 216  
 cloud infrastructure tools, 325  
 Cloudera, 14  
 cognitive analytics, 222  
 cognitive artificial intelligence, 84  
 cognitive science, 163  
 collective interactions, 102  
 common sense, 61  
 communicating with stakeholders, 42  
 Communication, 74  
 communication management, 192  
 communication studies, 197  
 competency ownership, 313  
 complex behaviors, 126  
 complex data, 108, 126  
 complex data science problem-solving, 163  
 complex data system, 70  
 complex environments, 126  
 complex findings, 127  
 complex models, 126  
 complex patterns, 98  
 complex relationships, 70  
 complex structures, 70  
 complex system, 68  
 complexity, 16, 71  
 computational and data-enabled science and engineering, 351  
 computational intelligence, 84, 173  
 computational performance, 116  
 computational science, 3  
 computational social science, 186  
 computational thinking, 359  
 computing, 176  
 computing challenges, 178  
 computing non-IIDness, 108  
 computing with data, 41  
 conceptualization, 60  
 connectionist AI, 215  
 connectionist intelligence, 215  
 context complexity, 96  
 coupled group behaviors, 153  
 coupling, 107, 109, 212  
 creative machines, 111  
 creative thinking, 62, 63  
 creative traits, 66

- creativity, 63
- CRISP-DM, 136
- critical data science thinking, 77
- critical thinking, 64
- critical thinking traits, 66
- critique, 64
- cross-domain data science, 100
- CSIRO, 24
- cultural data power, 15
- curiosity, 60, 110
  
- D**
- DARPA, 26
- data, 16, 31
- Data61, 24
- data, information, knowledge, intelligence & wisdom, 173
- data accountability, 122
- data administrator, 327
- data analysis, 5
- data analytical services, 260
- data analytical thinking, 72
- data analytics, 5, 11, 172
- data/analytics content, 252
- data/analytics design, 252
- data/analytics education, 253
- data/analytics industrialization, 259
- data/analytics infrastructure, 252
- data analytics quality, 115
- data/analytics services, 253
- data/analytics software, 252
- data analytics tools, 325
- data anomaly detection, 118
- data architect, 321, 327
- data A-Z, 145
- data brain, 356
- data-centric view, 35
- data change detection, 118
- data characteristics, 94, 148
- data complexities, 8, 94, 148, 310
- data consistency test, 118
- data consumers, 121
- data contrast analysis, 118
- data deluge, 3, 7, 30
- data DNA, 29, 33
- data+domain-driven discovery, 87
- data-driven, 85
- data-driven AI, 215
- data-driven discovery, 4, 10, 80, 81, 144
- data-driven economy, 20
- data-driven education, 20
- data-driven entertainment, 20
- data-driven evidence-based method, 189
- data-driven exploration, 85
- data-driven government, 20
- data-driven innovation, 20
- data-driven lifestyle, 20
- data-driven management, 154
- data-driven opportunities, 20
- data-driven research, 20
- data-driven science, 4
- data-driven science, technology, engineering and mathematics, 185
- data driving forces, 16
- data economic model, 243
- data economy, 9, 71, 237, 238
- data economy family, 238
- data economy features, 246
- data-enabling technological businesses, 239
- data engineer, 327
- data engineering, 177, 217
- data engineering responsibilities, 323
- data engineering tasks, 323
- data engineering techniques, 217
- data engineers, 320, 321
- data era features, 7
- data ethical norms, 124
- data ethics, 40, 123
- data ethics assurance, 124
- data executive, 327
- data existence, 7
- data exploration, 41
- data factor, 119
- data generalizability, 114
- data goal satisfaction, 310
- data governance team, 117
- data governors, 121
- data indicator, 119
- data industrialization, 9
- data industry, 251
- data infrastructure, 53
- data insights, 43
- data integration tools, 325
- data integrity, 114
- data intelligence, 19, 99
- data-intensive, 33
- data-intensive core businesses, 239
- data-intensive scientific discovery, 3
- data invisibility, 103
- datalogical, 33
- datalogy, 10
- data management, 192, 254
- data manipulation, 254
- data matching, 45, 118
- data maturity, 309
- data mining, 10, 172
- data misconduct, 125

- data modelers, 159, 327
- data monitoring, 118
- data objectivity, 114
- data openness, 122
- data organism, 34
- data-oriented driving forces, 16
- data over-conduct, 124
- data ownership, 121
- data potential, 129
- data power, 3, 14
- data preparation tools, 325
- data preprocessing, 40
- data presentation, 41
- data privacy, 122, 218
- data processing, 10
- data processing tools, 325
- data producers, 121
- data product, 29, 42, 48
- data product quality, 115, 116
- data products, 13, 238
- data profession, 71, 294
- data professionals, 319
- data profiling, 118
- data quality, 113, 115, 310
- data quality analytics, 118
- data quality assessment, 119
- data quality assurance, 116
- data quality checklists, 119
- data quality control, 116
- data quality indicator, 115
- data quality issues, 113, 115
- data quality measurement, 115
- data quantification, 7, 29, 30
- data quantitation, 30
- data relevance, 114
- data reliability, 114
- data research and development, 8
- data research initiatives, 27
- data research issues, 142
- data residency, 121
- data science, 5, 9, 29, 37
- data science agenda, 26
- data science and engineering, 4
- data science assurance, 76
- data science capabilities, 55
- data science challenges, 93, 140
- data science communications, 198, 302, 304
- data science community, 11
- data science course structure, 337
- data science courses, 330
- data science custody, 74
- data science debate, 6
- data science deliverables, 42, 76
- data science design, 88
- data science disciplines, 129, 331
- data science education, 329
- data science education framework, 337
- data science era, 5
- data science ethics, 123
- data science evaluation, 89
- data science feed, 74
- data science foundations, 161
- data science input, 88
- data science job, 9
- data science journey, 9
- data science knowledge base, 301
- data science leadership, 302
- data science management, 191, 193, 302
- data science maturity, 307, 308
- data science maturity model, 307
- data science mechanism design, 75
- data science methods, 88
- data science objectives, 88
- data science of sciences, 355
- data science-oriented computing, 178
- data science output, 89
- data science positions, 300
- data science practices, 201, 302
- data science processes, 88, 264
- data science professionals, 319
- data science project management, 266
- data science research, 294
- data science research areas, 145
- data science research map, 140
- data science roles, 55, 299
- data science skill set, 302
- data science success factors, 268
- data science team, 299, 321
- data science technical skills, 302
- data science theoretical foundation, 302
- data science thinking, 20, 37, 59, 111, 146, 147, 302
- data science thinking structure, 72
- data science thought, 73
- data science tools, 325
- data science training, 201
- data scientific communities, 295
- data scientist qualification, 318
- data scientist responsibilities, 315
- data scientists, 9, 313, 327
- data security, 122, 218
- data service businesses, 240
- data service models, 257
- data service providers, 121
- data services, 13, 257
- data social issues, 121
- data societies, 186
- data society governance, 187

- data source quality, 115
  - data sovereignty, 121
  - data standardization, 118
  - data startup, 8
  - data system engineer , 327
  - data systems, 13
  - datathing, 238
  - data-to-decision, 219
  - data-to-insight-to-decision transfer, 219
  - data trust, 122
  - data under-conduct, 124
  - data usability, 310
  - data utility, 114
  - data validity, 114
  - data value, 8
  - data value potential, 310
  - data values, 122
  - data variability, 114
  - data veracity, 114
  - data visualization, 41
  - data volume, 52
  - data world, 95
  - datafication, 7, 29
  - datafying, 30
  - decision strategist, 327
  - decision-making complexity, 18
  - deductive thinking, 63
  - deep analytics, 5
  - deep analytics, mining and learning, 172
  - deep behavior insight, 150
  - deep insights, 43
  - deep learning, 112, 211
  - deep learning tools, 325
  - DeepMind, 112
  - Defence Advanced Research Projects Agency, 26
  - deliverable complexity, 98
  - deliverable insight, 43
  - descriptive analysis, 41
  - descriptive analytics, 5, 10, 223
  - diagnostic analytics, 222
  - digitalization, 30
  - DIKIW, 173
  - DIKIW pyramid, 31, 173
  - DIKIW-processing, 38
  - dimensionality, 145
  - dimensionality reduction, 209
  - direct data values, 122
  - directed acyclic graph, 211
  - directed acyclic graphical model, 211
  - disciplinary capabilities, 129
  - disciplinary gaps, 129
  - disciplinary misconceptions, 50
  - discovering Knowledge, 41
  - divergence, 145
  - DNA, 32
  - domain, 86
  - domain complexity, 18, 95
  - domain+data-driven discovery, 87
  - domain-driven, 86
  - domain-driven data mining, 87
  - domain-driven exploration, 86
  - domain intelligence, 19, 100
  - domain knowledge, 200
  - domain-specific algorithms, 265
  - domain-specific analytics, 230
  - domain-specific data problems, 200
  - domain-specific data products, 13
  - domain-specific data science, 40
  - domain-specific data science problem, 200
  - domain-specific organizational capabilities, 312
  - domain-specific organizational strategies, 312
  - domain-specific X-analytics, 230, 231
  - DSAA, 11
  - dSTEM, 185
- E**
- economic data power, 14
  - effective communication skills, 306
  - effective communications, 304
  - electrification, 353
  - embedding, 145
  - empirical science, 3
  - entity, 33
  - environment complexity, 18, 96
  - environment intelligence, 103
  - environmental factors, 103
  - environmental intelligence, 19
  - European data initiatives, 25
  - European data science academy, 25
  - evaluation, 60
  - evidence, 36
  - evidence-based decision-making, 35
  - evidence-based management, 194
  - evolutionary learning, 210
  - exceptional trend, 210
  - excessive data fitting, 81
  - excessive model fitting, 82
  - existing data industries, 251
  - existing data services, 251
  - experimental design, 60, 83
  - experimental science, 3
  - expert knowledge, 200
  - explicit non-IIDness, 108
  - exploratory data analysis, 10
  - extreme data challenge, 125

**F**

feature, 209  
 feature engineering, 41, 209  
 first industrial revolution, 353  
 forecasting, 210  
 four progression layers, 72  
 four scientific paradigms, 4  
 the fourth revolution, 350  
 fourth science paradigm, 3  
 fourth scientific, technological and industrial revolution, 353  
 free software, 47  
 frequent itemset mining, 209  
 frequent sequence analysis, 209  
 functional and nonfunctional challenges, 174  
 fusion, 145  
 future, 16

**G**

G7 academies's joint statements, 350  
 general algorithms, 265  
 general application guidance, 264  
 general communication skills, 304  
 generalization, 213  
 genomics, 30  
 geometry, 208  
 goal-driven discovery, 143  
 Google Flu, 48  
 Google trends, 21  
 government data initiatives, 23  
 government scientific agenda, 26  
 graph theory, 208

**H**

Hadoop distributed file systems, 217  
 hard data science foundations, 162  
 hard intelligence, 358  
 hashing, 145  
 HDFS, 217  
 heterogeneity, 107, 145, 212  
 hidden knowledge space, 104  
 high dimensionality, 209  
 high performance processing tools, 326  
 holism, 72, 132, 133  
 human complexity, 18  
 human intelligence, 19, 84, 100, 110, 173  
 human social intelligence, 101, 102  
 human-like imaginary thinking, 112  
 human-like machine intelligence, 110  
 human-like machine thinking, 112  
 human-machine cooperation, 84  
 human-machine-cooperation complexities, 97

human-machine cooperative AI, 215  
 human-machine-cooperative cognitive computing and thinking, 359  
 human-machine interaction, 84  
 hypothesis testing, 60, 83  
 hypothesis-driven discovery, 82  
 hypothesis-driven paradigm, 183  
 hypothesis-free exploration, 35  
 hypothesis-free paradigm, 183

**I**

IBM Watson, 358  
 IEEE big data initiative, 297  
 IEEE Conference on Data Science and Advanced Analytics, 297  
 IEEE Task Force on Data Science and Advanced Analytics, 297  
 IID learning, 107, 212  
 IIDness, 107  
 imaginary thinking, 111  
 imagination, 111  
 imaginative thinking, 359  
 imperfect fitting, 82  
 imperfect modeling, 82  
 implicit non-IIDness, 108  
 importing and exporting, 157  
 independent and identically distributed (IID), 107, 212  
 indirect data values, 122  
 inductive thinking, 62  
 industrial IoT, 218  
 Industry 4.0, 216  
 industry transformation, 9  
 ineffective communication skills, 307  
 informatics, 35, 169  
 information, 31  
 information and communication technologies (ICT), 170  
 information processing, 10  
 information science, 167  
 information theory, 80, 208  
 innovative data products, 13  
 intelligence, 16, 31  
 intelligence meta-synthesis, 136  
 intelligence science, 172  
 intelligent datathings, 249  
 intelligent economy, 249  
 intelligent manufacturing, 216  
 intent, 73  
 interactive analytical systems, 157, 158  
 interactive learning systems, 158  
 interdisciplinary areas, 155  
 interdisciplinary capability set, 155

- interdisciplinary fusion, 161
- interest trend, 20
- International Conference on Machine Learning (ICML), 11
- Internet of Things, 33, 218
- intuition, 61
- IoT, 30, 33, 218
- IoT techniques, 218
  
- J**
- job survey, 320
- jungle, 145
  
- K**
- kernel, 210
- kernel method, 210
- kernelization, 145
- knowledge, 31
- knowledge discovery, 10, 41
- Knowledge Discovery in Databases (KDD), 10
- knowledge discovery scientist, 327
- known knowledge space, 104
  
- L**
- lateral thinking, 65
- learning complexities, 18, 97
- learning IID data, 107
- learning machine, 204
- learning non-IID data, 108
- learning performance, 116
- linkage, 145
- logical reasoning, 62
- logical thinking, 62, 359
  
- M**
- machine learning, 10, 172
- machine learning tools, 325
- machine thinking, 359
- macro level, 70
- management, 74
- management analytics, 196
- management data, 196
- management data science, 196
- management science, 190, 191
- managing data, 40
- MapReduce, 217
- master data management tools, 325
- Master in data science, 343
- mathematical and statistical thinking, 359
- mathematical thinking, 72
- mathematics, 165
- maturity, 308
- maturity model, 308
- memory emulation, 110
- meso level, 70
- metabolomics, 30
- meta-knowledge, 31
- metasynthesis, 84
- metasynthetic AI, 215
- metasynthetic analytics, 85
- metasynthetic computing and engineering, 137
- metasynthetic engineering, 135
- methodological adoption, 134
- metrology, 145
- microbiomics, 30
- micro level, 70
- micro-meso-societal level, 111
- migration, 145
- military data power, 15
- misconceptions, 49
- model management, 192
- model operator, 327
- model-based design, 80, 81
- model-based learning, 36
- model deployment manager, 327
- model-driven discovery, 82
- model-independent discovery, 35
- Moore Law, 356
- multi-agent learning systems, 158
- multidisciplinary view, 35
- multi-mode interactions, 157
- myths, 49
  
- N**
- National Institute of Standards and Technology, 26
- natural intelligence, 84, 173, 215
- nature-inspired AI, 215
- negative data power, 15
- network engineer, 327
- network intelligence, 19, 101
- Neural Information Processing Symposium (NIPS), 11
- new data economy, 9, 13, 239
- new data industries, 251, 252
- new data services, 251
- new economic models, 243
- new economy, 237
- new-generation data products, 13
- new generation statistical analysis, 166
- new-generation statistics, 165
- new social science methods, 185
- new X-generations, 17

next-generation artificial intelligence, 110  
 next-generation information science, 173  
 next-generation intelligence science, 173  
 next-generation management science, 195  
 NLP tools, 325  
 node, 211  
 non-digital businesses, 240  
 non-fitting, 82  
 non-IID, 107, 212  
 non-IID challenges, 108  
 non-IID learning, 70, 108, 212  
 non-IIDness, 107, 212  
 non-occurring behaviors, 80, 153  
 non-open data, 45  
 normalization, 145  
 numerical computation, 205

## O

objective management, 192  
 occurring behaviors, 153  
 OECD data-driven innovation, 350  
 off-the-shelf tools, 226  
 OLAP, 41  
 omics, 30, 312  
 online data science courses, 333  
 open access, 45, 47  
 open activities, 44  
 open data, 45  
 open environment, 103  
 open evaluation, 47  
 open government data, 45  
 open model, 44  
 open movements, 44  
 open problems, 70  
 open repositories, 45  
 open research and innovation, 46  
 open review, 47  
 open science, 46  
 open science data, 47  
 open source, 47, 158  
 open source software, 47  
 openness, 8, 44  
 openness principle, 44  
 optimization, 145, 213  
 organization intelligence, 101  
 organizational data science competency, 313  
 organizational data thinking, 312  
 organizational intelligence, 19  
 organizational management, 190  
 organizational maturity, 312  
 organizational policy maturity, 312  
 organizational practice maturity, 312  
 organizational strategy maturity, 312

other data initiatives, 26  
 outlier, 145

## P

paradigm metasynthesis, 84  
 partially organized data, 310  
 past data, 220  
 pattern recognition, 172  
 patternable trend, 210  
 people maturity, 312  
 perfect fitting, 81  
 perfectly organized data, 311  
 personal experience, 61  
 PhD in data science, 346  
 physical world, 95  
 planning and management maturity, 312  
 political data power, 15  
 positive data power, 15  
 predefined modeling blocks, 157  
 predictive analytics, 5, 224  
 prescriptive analytics, 5, 225  
 present data, 220  
 probabilistic dependency model, 211  
 probabilistic graphical models, 211  
 probability theory, 208  
 problem-driven discovery, 143  
 process management, 192  
 process-based data science formula, 39  
 process-driven data science, 39  
 professional data conduct, 124  
 programming language support, 157  
 programming tools, 325  
 project management, 157, 192  
 project management tools, 326  
 property, 33  
 proteomics, 30  
 provenance, 145

## Q

qualitative-to-quantitative cognition, 85  
 qualitative-to-quantitative cognitive process,  
 136  
 qualitative-to-quantitative metasynthesis, 137  
 quality management, 192  
 quantified self devices, 30

## R

rationalism, 61  
 reactive analytics, 220  
 real economy, 249  
 reductionism, 71, 132  
 regularization, 145, 213

reinforcement learning, 112, 212  
 relations, 78  
 relationship, 33  
 representation, 210  
 representation learning, 210  
 requirement management, 192  
 resource management, 192  
 restricted thinking, 64  
 risk management, 192  
 rule, 209  
 rule induction, 209  
 rule learning, 209

## S

scalability, 145  
 scientific data power, 14  
 scientific thinking, 60  
 second industrial revolution, 353  
 security-oriented data power, 15  
 semi-closed environment, 103  
 semi-open problems, 70  
 service, 16  
 set theory, 208  
 shallow analysis and processing, 172  
 Shannon theory, 80  
 situated AI, 215  
 situated intelligence, 215  
 smart e-bikes, 242  
 smart manufacturing, 216  
 social AI, 215  
 social complexity, 18, 96  
 social data issues, 186  
 social data power, 14  
 social data science, 180, 184, 188  
 social features, 182  
 social good, 186  
 social intelligence, 19, 102, 215  
 social methods, 180  
 social network analysis tools, 326  
 social network intelligence, 102  
 social problem-solving, 181  
 social science, 179  
 social science transformation, 184  
 Social theories, 180  
 social thinking, 180  
 social values, 310  
 socialization, 181  
 society, 181  
 soft data science foundations, 162  
 soft intelligence, 358  
 software development, 267  
 software engineer, 321

software quality assessment, 119  
 source domain, 212  
 Spark, 14  
 sparsity, 145  
 specific communication skills, 305  
 split testing, 83  
 sprint, 267  
 stakeholders, 42  
 statistical learning, 209  
 statistical theory, 208  
 statistical thinking, 72  
 statistical views, 34  
 statistics, 34, 165  
 statistics tools, 325  
 subjective autonomy, 48  
 sufficiently organized data, 311  
 supervised learning, 210  
 symbolic AI, 215  
 symbolic intelligence, 215  
 synthesizing X-intelligence, 135  
 system complexities, 69, 71, 137  
 system development life cycle, 266  
 systematic data science view, 68  
 systematic view, 68  
 systematism, 132, 133  
 systematological process, 134

## T

target domain, 212  
 team management, 192  
 technical data power, 14  
 technical values, 310  
 technological revolution, 353  
 tenacity, 61  
 theoretical performance, 116  
 theoretical science, 3  
 theoretical values, 310  
 thinking, 73  
 thinking characterizations, 60  
 thinking data-analytically, 53  
 thinking in data science, 59  
 thinking with evidence, 60  
 thinking with wisdom, 39  
 third industrial revolution, 353  
 3D printing, 355  
 three-stage analytics, 229  
 top-down holism, 72  
 top-down logic, 63  
 traditional businesses that utilize data poorly,  
     240  
 traditional economy, 249  
 trans-disciplinary data science, 38  
 transfer data science, 100

transfer learning, 212  
transformation, 145  
transforming traditional industries, 255  
trend, 210  
trend forecasting, 210  
two-sample hypothesis testing, 83

**U**

UN global pulse project, 26  
uncreative thinking, 63  
uncreative thinking habits, 64  
understanding the Domain, 40  
unknown challenges, 78  
unknown complexities, 78  
unknown gaps, 78  
unknown knowledge space, 105  
unknown opportunities, 79  
unknown solutions, 80  
unknown world, 78  
unorganized data, 310  
unscientific thinking, 61  
unsupervised learning, 209

**V**

vendor-dependent solutions, 265  
vendor-independent solutions, 265  
virtual economy, 249  
visualization and presentation, 157

visualization tools, 325  
von Neumann computer, 113

**W**

waterfall model, 266  
waterfall project management methodology,  
266  
we do not know what we do not know, 77, 221  
we know what we do not know, 221  
we know what we know, 220  
wearable devices, 30  
weighting, 145  
whole-of-life span of analytics, 219  
wisdom, 31  
workflow building, 157  
wrangling, 145  
www.datasciences.info, 5

**X**

X-analytics, 11, 20, 230  
X-complexities, 18, 32, 94  
XDATA program, 26  
X-informatics, 20, 169  
X-intelligence, 18, 32, 99  
X-opportunities, 19

**Z**

zettabyte, 145