Predicting Data Breaches with Machine Learning: A Focus on Data Type and Vulnerabilities (November 2023)

Y Sugiyama

George Mason University, Fairfax, VA 22030 USA

Corresponding author: Y Sugiyama (e-mail: ysugiyam@ protonmail.com).

ABSTRACT Data breaches pose challenges for organizations, necessitating a proactive approach to mitigate risks and grasp the underlying dynamics. This study uses machine learning, data science techniques, and NLP to predict Massachusetts data breaches, aiming to uncover patterns and susceptibility. Organizational susceptibility, data protection strategies, and motivations behind data breaches will be investigated. A Decision Tree Classifier on a cleaned, transformed, and normalized dataset with balanced representation was employed. The model achieves 81% accuracy in the training dataset and 80% in the test dataset, with only the two majority classes “Finance” and “Corporation”. This research emphasizes the need for comprehensive data collection, improved NLP, and model robustness. Future work will involve finding a more practical way to categorize these organizations using NLP, exploring more machine learning models, hyperparameter tuning, and collecting additional data, such as geographical locations, to further enhance predictive accuracy. Finally, the study emphasizes the importance of understanding and addressing the multifaceted challenges created by data breaches in diverse organizational contexts.

INDEX TERMS Enter key words or phrases in alphabetical order, separated by commas. Using the *IEEE Thesaurus* can help you find the best standardized keywords to fit your article. Use the [thesaurus access request form](https://www.ieee.org/publications/services/thesaurus-access-page.html) for free access to the *IEEE Thesaurus*.

I. INTRODUCTION

This is the template for Microsoft Word. The editable version is at https://template-selector.ieee.org/. If you would prefer to use LaTeX, download IEEE’s LaTeX style and sample files from the same Web page. You can also explore using the Overleaf editor at [https://www.overleaf.com/blog/278-how-to-use-overleaf-with-ieee-collabratec-your-quick-guide-to-getting-started#.Vp6tpPkrKM9](https://www.overleaf.com/blog/278-how-to-use-overleaf-with-ieee-collabratec-your-quick-guide-to-getting-started%23.Vp6tpPkrKM9)

This template is a guide to formatting; your proof and final published version may vary in layout and length to conform to IEEE policy and style. Page count is an estimate; the length of your submitted article in the template may not be the same as when the formal proof is created by IEEE

The *IEEE Editorial Style Manual for Authors* is available at <https://journals.ieeeauthorcenter.ieee.org/create-your-ieee-journal-article/create-the-text-of-your-article/ieee-editorial-style-manual/>. This contains a formal set of editorial guidelines for IEEE Transactions, Journals, and Letters, including:

* punctuation;
* capitalization;
* abbreviations;
* section headings;
* numbers, equations;
* footnotes;
* biographies;
* some common mistakes;
* units of measurement.

Communicate your work clearly. If you are not fully proficient in English, consider using an English language editing service before submitting your article. An expert editing service can help you refine the use of English in your article, so you can communicate your work more effectively.

The use of an editing service is paid for by the author. It does not guarantee acceptance in an IEEE publication. For more information, visit the IEEE Author Center at <https://journals.ieeeauthorcenter.ieee.org/create-your-ieee-journal-article/create-the-text-of-your-article/structure-your-article/#editing-service>.

II. GUIDELINES FOR MANUSCRIPT PREPARATION

Z:\Indesign Projects\005 Series\03 OA Word templates\Work\TJ\Work\Fig3.tifWhen you open the template, select “Page Layout” from the “View” menu in the menu bar (View | Page Layout), (these instructions assume Microsoft *Word*. Some versions may alternate ways to access the same functionalities noted here). Then, type over sections of the template or cut and paste from another document and use markup styles. The pull-down style menu is in the Formatting Toolbar at the top of your Word window (e.g., the style at this point in the document is “Text”). Highlight a section that you want to designate with a certain style, and then select the appropriate name on the style menu. The style will adjust your fonts and line spacing. Do not change the font sizes or line spacing to squeeze more text into a limited number of pages. Use italics for emphasis; do not underline.

IEEE will do the final formatting of your paper. If your paper is intended for a conference, please observe the conference page limits.

This is intended as an authoring template, not a final production template. It is not intended to match the final published format. Differences in final formatting are likely in the final IEEE files. Page count in the template is an estimate. Do not adjust line and character spacing to fit your paper to a specific length.

A. ABBREVIATIONS AND ACRONYMS

Define abbreviations and acronyms the first time they are used in the text, even after they have already been defined in the abstract. Abbreviations such as IEEE, SI, ac, and dc do not have to be defined. Abbreviations that incorporate periods should not have spaces: write “C.N.R.S.,” not “C. N. R. S.” Do not use abbreviations in the title unless they are unavoidable (for example, “IEEE” in the title of this article).

III. MATH

Use either the Microsoft Equation Editor or the MathType plugin, which can be obtained from [https://store.wiris.com/en/  
products/mathtype/download](https://store.wiris.com/en/products/mathtype/download). For help with formatting and placing equations, refer to the IEEE Editing Math Guide at [http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/  
sites/7/Editing-Mathematics.pdf](http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/Editing-Mathematics.pdf) and the IEEE MathType Tutorial for Microsoft Word Users at [http://journals.  
ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE-Math-Typesetting-Guide-for-MS-Word-Users.pdf](http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE-Math-Typesetting-Guide-for-MS-Word-Users.pdf).

A. EQUATIONS

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First use the equation editor to create the equation. Then select the “Equation” markup style. Press the tab key and write the equation number in parentheses. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Use parentheses to avoid ambiguities in denominators. Punctuate equations when they are part of a sentence, as in

E = mc2. (1)

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (T might refer to temperature, but T is the unit tesla). Refer to “(1),” not “Eq. (1)” or “equation (1),” except at the beginning of a sentence: “Equation (1) is ... .”

B. Algorithms

Algorithms should be numbered and include a short title. They are set off from the text with rules above and below the title and after the last line.

IV. UNITS

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary units (in parentheses). This applies to papers in data storage. For example, write “15 Gb/cm2 (100 Gb/in2).” An exception is when English units are used as identifiers in trade, such as “3½-in disk drive.” Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.

The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as µ0H. Use the center dot to separate compound units, e.g., “A·m2.”

V. SOME COMMON MISTAKES

The word “data” is plural, not singular. The subscript for the permeability of vacuum µ0 is zero, not a lowercase letter “o.” The term for residual magnetization is “remanence”; the adjective is “remanent”; do not write “remnance” or “remnant.” Use the word “micrometer” instead of “micron.” A graph within a graph is an “inset,” not an “insert.” The word “alternatively” is preferred to the word “alternately” (unless you really mean something that alternates). Use the word “whereas” instead of “while” (unless you are referring to simultaneous events). Do not use the word “essentially” to mean “approximately” or “effectively.” Do not use the word “issue” as a euphemism for “problem.” When compositions are not specified, separate chemical symbols by en-dashes; for example, “NiMn” indicates the intermetallic compound Ni0.5Mn0.5 whereas “Ni–Mn” indicates an alloy of some composition NixMn1-x.

Be aware of the different meanings of the homophones “affect” (usually a verb) and “effect” (usually a noun), “complement” and “compliment,” “discreet” and “discrete,” “principal” (e.g., “principal investigator”) and “principle” (e.g., “principle of measurement”). Do not confuse “imply” and “infer.”

Prefixes such as “non,” “sub,” “micro,” “multi,” and “ultra” are not independent words; they should be joined to the words they modify, usually without a hyphen. There is no period after the “et” in the Latin abbreviation “et al.” (it is also italicized). The abbreviation “i.e.,” means “that is,” and the abbreviation “e.g.,” means “for example” (these abbreviations are not italicized).

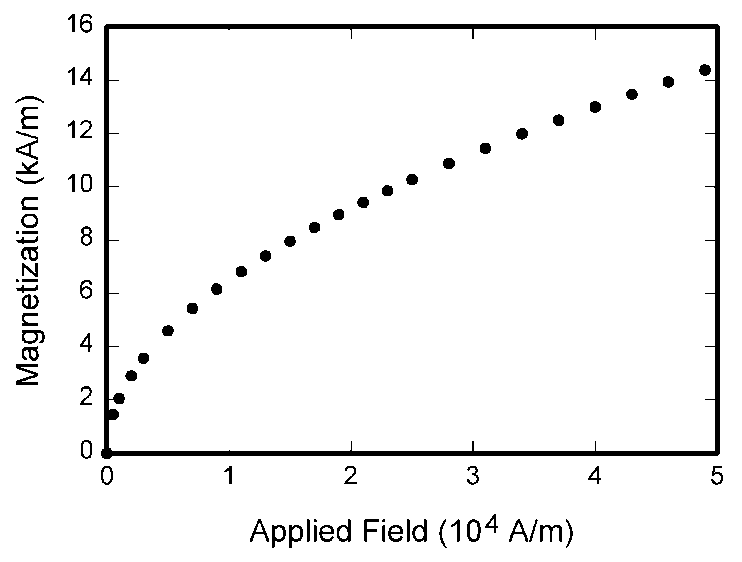


FIGURE 1.  Magnetization as a function of applied field. Note that “Fig.” is abbreviated. There is a period after the figure number, followed by two spaces. It is good practice to explain the significance of the figure in the caption.

VI. GUIDELINES FOR GRAPHICS PREPARATION   
AND SUBMISSION

A.  TYPES OF GRAPHICS

The following list outlines the different types of graphics published in IEEE journals. They are categorized based on their construction, and use of color / shades of gray:

1) Color/Grayscale figures

Figures that are meant to appear in color, or shades of black/gray. Such figures may include photographs, illustrations, multicolor graphs, and flowcharts.

2) Line Art figures

Figures that are composed of only black lines and shapes. These figures should have no shades or half-tones of gray, only black and white.

3)  PHOTOS, INCLUDING Author photos

True photos may be in JPEG format (.JPG), but JPEG should not be used for computer-generated images. Head and shoulders photos of authors appear at the end of our papers.

4) Tables

Data charts which are typically black and white, but sometimes include color.

B. MULTIPART FIGURES

Figures compiled of more than one sub-figure presented side-by-side, or stacked. If a multipart figure is made up of multiple figure types (one part is lineart, and another is grayscale or color) the figure should meet the stricter guidelines.

C. FILE FORMATS FOR GRAPHICS

Format and save your graphics using a suitable graphics processing program that will allow you to create the images as PostScript (.PS), Encapsulated PostScript (.EPS), Tagged Image File Format (.TIFF), Portable Document Format (.PDF), or Portable Network Graphics (.PNG) sizes them, and adjusts the resolution settings. If you created your source files in one of the following programs you will be able to submit the graphics without converting to a PS, EPS, TIFF, PDF, or PNG file: Microsoft Word, Microsoft PowerPoint, or Microsoft Excel. Though it is not required, it is strongly recommended that these files be saved in PDF format rather than DOC, XLS, or PPT. Doing so will protect your figures from common font and arrow stroke issues that occur when working on the files across multiple platforms. When submitting your final paper, your graphics should all be submitted individually in one of these formats along with the manuscript.

D. SIZING OF GRAPHICS

Most charts, graphs, and tables are one column wide (3.5 inches / 88 millimeters / 21 picas) or page wide (7.16 inches / 181 millimeters / 43 picas). The maximum depth a graphic

TABLE 1

Units for Magnetic Properties

|  |  |  |
| --- | --- | --- |
| Symbol | Quantity | Conversion from Gaussian and  CGS EMU to SI a |
| Φ | magnetic flux | 1 Mx → 10−8 Wb = 10−8 V·s |
| *B* | magnetic flux density,  magnetic induction | 1 G → 10−4 T = 10−4 Wb/m2 |
| *H* | magnetic field strength | 1 Oe → 103/(4π) A/m |
| *m* | magnetic moment | 1 erg/G = 1 emu  → 10−3 A·m2 = 10−3 J/T |
| *M* | magnetization | 1 erg/(G·cm3) = 1 emu/cm3  → 103 A/m |
| 4π*M* | magnetization | 1 G → 103/(4π) A/m |
| σ | specific magnetization | 1 erg/(G·g) = 1 emu/g → 1 A·m2/kg |
| *j* | magnetic dipole  moment | 1 erg/G = 1 emu  → 4π × 10−10 Wb·m |
| *J* | magnetic polarization | 1 erg/(G·cm3) = 1 emu/cm3  → 4π × 10−4 T |
| χ*,* κ | susceptibility | 1 → 4π |
| χρ | mass susceptibility | 1 cm3/g → 4π × 10−3 m3/kg |
| μ | permeability | 1 → 4π × 10−7 H/m  = 4π × 10−7 Wb/(A·m) |
| μr | relative permeability | μ → μr |
| *w, W* | energy density | 1 erg/cm3 → 10−1 J/m3 |
| *N, D* | demagnetizing factor | 1 → 1/(4π) |

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

aGaussian units are the same as cg emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

can be is 8.5 inches (216 millimeters / 54 picas). When choosing the depth of a graphic, please allow space for a caption. Figures can be sized between column and page widths if the author chooses, however it is recommended that figures are not sized less than column width unless when necessary.

The final printed size of author photographs is exactly   
1 inch wide by 1.25 inches tall (25.4 millimeters x 31.75 millimeters / 6 picas x 7.5 picas). Author photos printed in editorials measure 1.59 inches wide by 2 inches tall (40 millimeters x 50 millimeters / 9.5 picas x 12 picas).

E. RESOLUTION

The proper resolution of your figures will depend on the type of figure it is as defined in the “Types of Figures” section. Author photographs, color, and grayscale figures should be at least 300dpi. Line art, including tables should be a minimum of 600dpi.

F. VECTOR ART

In order to preserve the figures’ integrity across multiple computer platforms, we accept files in the following formats: .EPS/.PDF/.PS. All fonts must be embedded or text converted to outlines in order to achieve the best-quality results.

G. COLOR SPACE

The term color space refers to the entire sum of colors that can be represented within the said medium. For our purposes, the three main color spaces are Grayscale, RGB (red/green/blue) and CMYK (cyan/magenta/yellow/black). RGB is generally used with on-screen graphics, whereas CMYK is used for printing purposes.

All color figures should be generated in RGB or CMYK color space. Grayscale images should be submitted in Grayscale color space. Line art may be provided in grayscale OR bitmap colorspace. Note that “bitmap colorspace” and “bitmap file format” are not the same thing. When bitmap color space is selected, .TIF/.TIFF/.PNG are the recommended file formats.

H. ACCEPTED FONTS WITHIN FIGURES

When preparing your graphics IEEE suggests that you use of one of the following Open Type fonts: Times New Roman, Helvetica, Arial, Cambria, and Symbol. If you are supplying EPS, PS, or PDF files all fonts must be embedded. Some fonts may only be native to your operating system; without the fonts embedded, parts of the graphic may be distorted or missing.

A safe option when finalizing your figures is to strip out the fonts before you save the files, creating “outline” type. This converts fonts to artwork what will appear uniformly on any screen.

I. USING LABELS WITHIN FIGURES

1) Figure Axis labels

Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity “Magnetization,” or “Magnetization M,” not just “M.” Put units in parentheses. Do not label axes only with units. As in Fig. 1, for example, write “Magnetization (A/m)” or “Magnetization (Am−1),” not just “A/m.” Do not label axes with a ratio of quantities and units. For example, write “Temperature (K),” not “Temperature/K.”

Multipliers can be especially confusing. Write “Magnetization (kA/m)” or “Magnetization (103 A/m).” Do not write “Magnetization (A/m) × 1000” because the reader would not know whether the top axis label in Fig. 1 meant 16000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8 to 10 point type.

2)  Subfigure Labels in Multipart Figures and Tables

Multipart figures should be combined and labeled before final submission. Labels should appear centered below each subfigure in 8 point Times New Roman font in the format of (a) (b) (c).

J. FILE NAMING

Figures (line artwork or photographs) should be named starting with the first 5 letters of the author’s last name. The next characters in the filename should be the number that represents the sequential location of this image in your article. For example, in author “Anderson’s” paper, the first three figures would be named ander1.tif, ander2.tif, and ander3.ps.

Tables should contain only the body of the table (not the caption) and should be named similarly to figures, except that “.t” is inserted in-between the author’s name and the table number. For example, author Anderson’s first three tables would be named ander.t1.tif, ander.t2.ps, ander.t3.eps.

Author photographs should be named using the first five characters of the pictured author’s last name. For example, four author photographs for a paper may be named: oppen.ps, moshc.tif, chen.eps, and duran.pdf.

If two authors or more have the same last name, their first initial(s) can be substituted for the fifth, fourth, third... letters of their surname until the degree where there is differentiation. For example, two authors Michael and Monica Oppenheimer’s photos would be named oppmi.tif, and oppmo.eps.

K. REFERENCING A FIGURE OR TABLE WITHIN YOUR PAPER

When referencing your figures and tables within your paper, use the abbreviation “Fig.” even at the beginning of a sentence. Do not abbreviate “Table.” Tables should be numbered with Arabic Numerals.

L. SUBMITTING YOUR GRAPHICS

Because IEEE will do the final formatting of your paper, you do not need to position figures and tables at the top and bottom of each column. In fact, all figures, figure captions, and tables can be placed at the end of your paper. In addition to, or even in lieu of submitting figures within your final manuscript, figures should be submitted individually, separate from the manuscript in one of the file formats listed above in Section VI-J. Place figure captions below the figures; place table titles above the tables. Please do not include captions as part of the figures, or put them in “text boxes” linked to the figures. Also, do not place borders around the outside of your figures.

M. COLOR PROCESSING / PRINTING IN IEEE JOURNALS

As an electronically published journal, TMLCN allows authors to use color without extra charge.

VII. CONCLUSION

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

APPENDIX

Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” In most cases, sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page, not here.

REFERENCES AND FOOTNOTES

A. REFERENCES

References need not be cited in text. When they are, they appear on the line, in square brackets, inside the punctuation. Multiple references are each numbered with separate brackets. When citing a section in a book, please give the relevant page numbers. In text, refer simply to the reference number. Do not use “Ref.” or “reference” except at the beginning of a sentence: “Reference [3] shows ... .” Please do not use automatic endnotes in Word, rather, type the reference list at the end of the paper using the “References” style.

Reference numbers are set flush left and form a column of their own, hanging out beyond the body of the reference. The reference numbers are on the line, enclosed in square brackets. In all references, the given name of the author or editor is abbreviated to the initial only and precedes the last name. Use them all; use et al. only if names are not given. Do not use commas around Jr., Sr., and III in names. Abbreviate conference titles. When citing IEEE transactions, provide the issue number, page range, volume number, year, and/or month if available. When referencing a patent, provide the day and the month of issue, or application. References may not include all information; please obtain and include relevant information. Do not combine references. There must be only one reference with each number. If there is a URL included with the print reference, it can be included at the end of the reference.

Other than books, capitalize only the first word in a paper title, except for proper nouns and element symbols. For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation. See the end of this document for formats and examples of common references. For a complete discussion of references and their formats, see the *IEEE Editorial Style Manual* *for Authors* at [https://journals.  
ieeeauthorcenter.ieee.org/create-your-ieee-journal-article/create-the-text-of-your-article/ieee-editorial-style-manual/](https://journals.ieeeauthorcenter.ieee.org/create-your-ieee-journal-article/create-the-text-of-your-article/ieee-editorial-style-manual/).

B. FOOTNOTES

Number footnotes separately in superscripts (Insert| Footnote).[[1]](#footnote-1) Place the actual footnote at the bottom of the column in which it is cited; do not put footnotes in the reference list (endnotes). Use letters for table footnotes (see Table 1).

VIII. SUBMITTING YOUR ARTICLE FOR REVIEW

A. REVIEW STAGE

Contributions to the Transactions, Journals, and Letters may be submitted electronically on IEEE’s Author Portal. You can get help choosing the correct publication for your manuscript as well as find their peer review site using the tools listed at [http://www.ieee.org/publications\_ standards/publications/authors/authors\_submission.html](http://www.ieee.org/publications_%20standards/publications/authors/authors_submission.html). Once you have chosen your publication and navigated to the IEEE Author Portal, you may log in with your IEEE account. If you do not have an account, you will be able to create a new one. After logging in, go to your Author Center and click “Start New Submission.”

Along with other information, you will be asked to select the manuscript type from the journal’s pre-determined list of options. Depending on the journal, there are various steps to the submission process; please make sure to carefully answer all of the submission questions presented to you. At the end of each step you must click “Save and Continue”; just uploading the paper is not sufficient. After the last step, you should see a confirmation that the submission is complete. You should also receive an e-mail confirmation. For inquiries regarding the submission of your paper on IEEE Author Portal, please contact oprs-support@ieee.org or call +1 732 465 5861.

IEEE Author Portal will accept files for review in various formats. There is a “Journal Home” link on the log-in page of each IEEE Author Portal site that will bring you to the journal’s homepage with their detailed requirements; please check these guidelines for your particular journal before you submit.

B. FINAL STAGE USING IEEE AUTHOR PORTAL

Upon acceptance, you will receive an email with specific instructions regarding the submission of your final files. Final submissions should include a nicely formatted pdf of the entire article as well as source files of your accepted manuscript, including high quality graphic files. If you have any questions regarding the final submission process, please contact the administrative contact for the journal.

TMLCN’s early access feature means the last pdf file provided during the peer review process will be quickly posted in IEEE Xplore—to be replaced with the final edited version when available. This feature allows the author to distribute permanent URLs to the community earlier. However, early access makes the author responsible for submitting a publicly presentable file. This makes it advisable for the author to scan their document for proprietary information markings, notes to reviewers, TODOs, and so forth.

C. COPYRIGHT

TMLCN uses the Creative Commons license CC BY. This is a standardized, highly permissive license that gives anybody the right to copy, redistribute, and remix the material provided that attribution is given. For more information see https://creativecommons.org/licenses/by/4.0/. Authors will be prompted to agree to the license by the submission system. You are responsible for obtaining any necessary approvals and/or security clearances. For additional information on intellectual property rights, visit the IEEE Intellectual Property Rights department web page at https://www.ieee.org/publications/rights/index.html.

IX. IEEE GUIDELINES AND POLICIES

A full overview of IEEE publishing guidelines and policies can be found at [https://journals.ieeeauthorcenter.ieee.org/  
become-an-ieee-journal-author/publishing-ethics/guidelines-and-policies/](https://journals.ieeeauthorcenter.ieee.org/become-an-ieee-journal-author/publishing-ethics/guidelines-and-policies/). They are designed to help authors understand and navigate the publishing process successfully. Learn more about IEEE’s fundamental publishing guidelines and principles, submission and peer review policies, post-publication policies, and guidelines on advertising, accessibility, and data privacy.

REFERENCES

*Basic format for books:*

J. K. Author, “Title of chapter in the book,” in *Title of His Published Book, x*th ed. City of Publisher, (only U.S. State), Country: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx.*

*Examples:*

1. G. O. Young, “Synthetic structure of industrial plastics,” in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15–64.
2. W.-K. Chen, *Linear Networks and Systems.* Belmont, CA, USA: Wadsworth, 1993, pp. 123–135.

*Basic format for periodicals:*

J. K. Author, “Name of paper,” *Abbrev. Title of Periodical*, vol. *x, no*. *x,* pp*. xxx-xxx,* Abbrev. Month, year, DOI. 10.1109.*XXX*.123456.

*Examples:*

1. J. U. Duncombe, “Infrared navigation—Part I: An assessment of feasibility,” *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34–39, Jan. 1959, doi:. 10.1109/TED.2016.2628402.
2. E. P. Wigner, “Theory of traveling-wave optical laser,” *Phys. Rev*., vol. 134, pp. A635–A646, Dec. 1965, doi: 10.1109.*XXX*.123456.
3. E. H. Miller, “A note on reflector arrays,” *IEEE Trans. Antennas Propagat*., to be published.

*Basic format for reports:*

J. K. Author, “Title of report,” Abbrev. Name of Co., City of Co., Abbrev. State, Country, Rep. *xxx*, year.

*Examples:*

1. E. E. Reber, R. L. Michell, and C. J. Carter, “Oxygen absorption in the earth’s atmosphere,” Aerospace Corp., Los Angeles, CA, USA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.
2. J. H. Davis and J. R. Cogdell, “Calibration program for the 16-foot antenna,” Elect. Eng. Res. Lab., Univ. Texas, Austin, TX, USA, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

*Basic format for handbooks:*

*Name of Manual/Handbook, x* ed., Abbrev. Name of Co., City of Co., Abbrev. State, Country, year, pp. *xxx-xxx.*

*Examples:*

1. *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, USA, 1985, pp. 44–60.
2. *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, USA, 1989.

*Basic format for books (when available online):*

J. K. Author, “Title of chapter in the book,” in *Title of Published Book*, *x*th ed. City of Publisher, State, Country: Abbrev. of Publisher, year, ch.*x*, sec. *x*, pp. *xxx–xxx*. [Online]. Available: http://www.web.com

*Examples:*

1. G. O. Young, “Synthetic structure of industrial plastics,” in Plastics, vol. 3, Polymers of Hexadromicon, J. Peters, Ed., 2nd ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15-64. [Online]. Available: http://www.bookref.com.
2. *The Founders’ Constitution*, Philip B. Kurland and Ralph Lerner, eds., Chicago, IL, USA: Univ. Chicago Press, 1987. [Online]. Available: http://press-pubs.uchicago.edu/founders/
3. The Terahertz Wave eBook. ZOmega Terahertz Corp., 2014. [Online]. Available: http://dl.z-thz.com/eBook/zomega\_  
   ebook\_pdf\_1206\_sr.pdf. Accessed on: May 19, 2014.
4. Philip B. Kurland and Ralph Lerner, eds., *The Founders’ Constitution.* Chicago, IL, USA: Univ. of Chicago Press, 1987, Accessed on: Feb. 28, 2010, [Online] Available: http://press-pubs.uchicago.edu/founders/

*Basic format for journals (when available online):*

J. K. Author, “Name of paper,” *Abbrev. Title of Periodical*, vol. *x*, no. *x*, pp. *xxx-xxx*, Abbrev. Month, year. Accessed on: Month, Day, year, doi: 10.1109.*XXX*.123456, [Online].

*Examples:*

1. J. S. Turner, “New directions in communications,” *IEEE J. Sel. Areas Commun*., vol. 13, no. 1, pp. 11-23, Jan. 1995. DOI. 10.1109.*XXX*.123456.
2. W. P. Risk, G. S. Kino, and H. J. Shaw, “Fiber-optic frequency shifter using a surface acoustic wave incident at an oblique angle,” *Opt. Lett.*, vol. 11, no. 2, pp. 115–117, Feb. 1986, doi: 10.1109.*XXX*.123456.
3. P. Kopyt *et al., “*Electric properties of graphene-based conductive layers from DC up to terahertz range,” *IEEE THz Sci. Technol.,* to be published, doi: 10.1109/TTHZ.2016.2544142.

*Basic format for papers presented at conferences (when available online):*

J.K. Author. (year, month). Title. presented at abbrev. conference title. [Type of Medium]. Available: site/path/file

*Example:*

1. PROCESS Corporation, Boston, MA, USA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. Presented at INET96 Annual Meeting. [Online]. Available: http://home.process.com/Intranets/wp2.htp

*Basic format for reports and handbooks (when available online):*

J. K. Author. “Title of report,” Company. City, State, Country. Rep. no., (optional: vol./issue), Date. [Online] Available: site/path/file

*Examples:*

1. R. J. Hijmans and J. van Etten, “Raster: Geographic analysis and modeling with raster data,” R Package Version 2.0-12, Jan. 12, 2012. [Online]. Available: http://CRAN.R-project.org/package=raster
2. Teralyzer. Lytera UG, Kirchhain, Germany [Online]. Available: http://www.lytera.de/Terahertz\_THz\_Spectroscopy.php?id=home, Accessed on: Jun. 5, 2014

*Basic format for computer programs and electronic documents (when available online):*

Legislative body. Number of Congress, Session. (year, month day). *Number of bill or resolution*, *Title*. [Type of medium]. Available: site/path/file

***NOTE:*** ISO recommends that capitalization follow the accepted practice for the language or script in which the information is given.

*Example:*

1. U.S. House. 102nd Congress, 1st Session. (1991, Jan. 11). *H. Con. Res. 1, Sense of the Congress on Approval of Military Action*. [Online]. Available: LEXIS Library: GENFED File: BILLS

*Basic format for patents (when available online):*

Name of the invention, by inventor’s name. (year, month day). Patent Number[Type of medium]. Available: site/path/file

*Example:*

1. Musical toothbrush with mirror, by L.M.R. Brooks. (1992,   
   May 19). Patent D 326 189

[Online]. Available: NEXIS Library: LEXPAT File: DES

*Basic format for conference proceedings (published):*

J. K. Author, “Title of paper,” in *Abbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), Country, year, pp. *xxxxxx.*

*Example:*

1. D. B. Payne and J. R. Stern, “Wavelength-switched pas- sively coupled single-mode optical network,” in *Proc. IOOC-ECOC,* Boston, MA, USA,1985, pp. 585–590, doi: 10.1109.*XXX*.123456.

*Example for papers presented at conferences (unpublished):*

1. D. Ebehard and E. Voges, “Digital single sideband detection for interferometric sensors,” presented at the *2nd Int. Conf. Optical Fiber Sensors,* Stuttgart, Germany, Jan. 2-5, 1984.

*Basic format for patents:*

J. K. Author, “Title of patent,” U.S. Patent *x xxx xxx*, Abbrev. Month, day, year.

*Example:*

1. G. Brandli and M. Dick, “Alternating current fed power supply,” U.S. Patent 4 084 217, Nov. 4, 1978.

*Basic format**for theses (M.S.) and dissertations (Ph.D.):*

a) J. K. Author, “Title of thesis,” M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

b) J. K. Author, “Title of dissertation,” Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

*Examples:*

1. J. O. Williams, “Narrow-band analyzer,” Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, USA, 1993.
2. N. Kawasaki, “Parametric study of thermal and chemical nonequilibrium nozzle flow,” M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

*Basic format for the most common types of unpublished references:*

a) J. K. Author, private communication, Abbrev. Month, year.

b) J. K. Author, “Title of paper,” unpublished.

c) J. K. Author, “Title of paper,” to be published.

*Examples:*

1. A. Harrison, private communication, May 1995.
2. B. Smith, “An approach to graphs of linear forms,” unpublished.
3. A. Brahms, “Representation error for real numbers in binary computer arithmetic,” IEEE Computer Group Repository, Paper R-67-85.

*Basic formats for standards:*

a) *Title of Standard*, Standard number, date.

b) *Title of Standard*, Standard number, Corporate author, location, date.

*Examples:*

1. IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.
2. Letter Symbols for Quantities, ANSI Standard Y10.5-1968.

*Article number in reference examples:*

1. R. Fardel, M. Nagel, F. Nuesch, T. Lippert, and A. Wokaun, “Fabrication of organic light emitting diode pixels by laser-assisted forward transfer,” *Appl. Phys. Lett.*, vol. 91, no. 6, Aug. 2007, Art. no. 061103, doi: 10.1109.*XXX*.123456.
2. J. Zhang and N. Tansu, “Optical gain and laser characteristics of InGaN quantum wells on ternary InGaN substrates,” *IEEE Photon. J.*, vol. 5, no. 2, Apr. 2013, Art. no. 2600111, doi: 10.1109.*XXX*.123456.

*Example when using et al.:*

1. S. Azodolmolky *et al.*, Experimental demonstration of an impairment aware network planning and operation tool for transparent/translucent optical networks,” *J. Lightw. Technol.*, vol. 29, no. 4, pp. 439–448, Sep. 2011, doi: 10.1109.*XXX*.123456.

The second paragraph uses the pronoun of the person (he or she) and not the author’s last name. It lists military and work experience, including summer and fellowship jobs. Job titles are capitalized. The current job must have a location; previous positions may be listed without one. Information concerning previous publications may be included. Try not to list more than three books or published articles. The format for listing publishers of a book within the biography is: title of book (publisher name, year) similar to a reference. Current and previous research interests end the paragraph.

The third paragraph begins with the author’s title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). List any memberships in professional societies other than the IEEE. Finally, list any awards and work for IEEE committees and publications. If a photograph is provided, it should be of good quality, and professional-looking.

1. It is recommended that footnotes be avoided. Instead, try to integrate the footnote information into the text. [↑](#footnote-ref-1)