# Credibility in Information Retrieval

Alexandru L. Ginsca
CEA, LIST, 91190 Gif-sur-Yvette, France
alexandru.ginsca@cea.fr

Adrian Popescu
CEA, LIST, 91190 Gif-sur-Yvette, France
adrian.popescu@cea.fr

Mihai Lupu
Vienna University of Technology, Austria
lupu@ifs.tuwien.ac.at

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adrian.popescu@cea.fr

Mihai Lupu
Vienna University of Technology, Austria
lupu@ifs.tuwien.ac.at

Contents

Abstract

Credibility, as the general concept covering trustworthiness and expertise, but also quality and reliability, is strongly debated in philosophy, psychology, and sociology, and its adoption in computer science is therefore fraught with difficulties. Yet its importance has grown in the information access community because of two complementing factors: on one hand, it is relatively difficult to precisely point to the source of a piece of information, and on the other hand, complex algorithms, statistical machine learning, artificial intelligence, make decisions on behalf of the users, with little oversight from the users themselves.

This survey presents a detailed analysis of existing credibility models from different information seeking research areas, with focus on the Web and its pervasive social component. It shows that there is a very rich body of work pertaining to different aspects and interpretations of credibility, particularly for different types of textual content (e.g., Web sites, blogs, tweets), but also to other modalities (videos, images, audio) and topics (e.g., health care). After an introduction placing credibility in the context of other sciences and relating it to trust, we argue for a quartic decomposition of credibility: expertise and trustworthiness, well documented in the literature and predominantly related to information source, and quality and reliability, raised to the status of equal partners because the source is often impossible to detect, and predominantly related to the content.

The second half of the survey provides the reader with access points to the literature, grouped by research interests. Section 3 reviews general research directions: the factors that contribute to credibility assessment in human consumers of information; the models used to combine these factors; the methods to predict credibility. A smaller section is dedicated to informing users about the credibility learned from the data. Sections 4, 5, and 6 go further into details, with domain-specific credibility, social media credibility, and multimedia credibility, respectively. While each of them is best understood in the context of Sections 1 and 2, they can be read independently of each other.

The last section of this survey addresses a topic not commonly considered under "credibility": the credibility of the system itself, in-

dependent of the data creators. This is a topic of particular importance in domains where the user is professionally motivated and where there are no concerns about the credibility of the data (e.g., e-discovery and patent search). While there is little explicit work in this direction, we argue that this is an open research direction that is worthy of future exploration.

Finally, as an additional help to the reader, an appendix lists the existing test collections that cater specifically to some aspect of credibility.

Overall, this review will provide the reader with an organised and comprehensive reference guide to the state of the art and the problems at hand, rather than a final answer to the question of what credibility is for computer science. Even within the relatively limited scope of an exact science, such an answer is not possible for a concept that is itself widely debated in philosophy and social sciences.

1

Introduction

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credibility

— *the quality that somebody/something has that makes people believe or trust them* (Oxford Advanced Learner's Dictionary)
— *the fact that someone can be believed or trusted* (Cambridge Advanced Learner's Dictionary & Thesaurus, 4th Edition)
— *the quality of being believed or accepted as true, real, or honest* (Merriam-Webster.com Aug 2015)
— *the quality of being believable or worthy of trust* (Dictionary.com Unabridged, Aug 2015)
— *the quality of being believed or trusted* (Collins English Dictionary, 2012 Digital Edition)
— *1. the quality, capability, or power to elicit belief / 2. A capacity for belief* (American Heritage Dictionary of the English Language, 5th Edition)
— *qualities that someone has that make people believe or trust them / a. used about things such as systems, statements, or beliefs* (Macmillan Dictionary)
— *the quality of deserving to be believed and trusted* (Longman Dictionary of Contemporary English)

Above we illustrate the fact that eight dictionaries of the English language provide eight different definitions of the object of our study. Superficially similar, the eight definitions are sometimes fundamentally different. Some refer to qualities of speaker, others to states of matter,

facts. Some refer to qualities with a concrete effect (believed, trusted, accepted), others to qualities with a potential effect (eliciting, deserving belief, or "can be believed"). All use a variant of the term "belief", implying the transfer of knowledge, but only six of eight use the term "trust" or variants thereof.

Credibility is therefore difficult to pinpoint. It is certainly not something that as computer science scholars we had imagined we would be concerned with. Computers are precise and their answers correct or formally verifiable. Yet two factors have in the past decade made credibility an issue in computer science. First, the input: a computer is only correct as long as its input is correct. With now the vast majority of content being generated by more or less hidden authors, credibility studies attempt to verify the correctness (in a very general understanding of the word) of this input. Second, the pervasiveness of statistical machine learning in many aspects of information access. The user is distant from the decision making process and generally unable to comprehend the intricacies of the decision-making process that ultimately shows him or her some information pieces but not others.

This survey will define the limits of credibility with respect to digital information access systems. Fundamentally, the discussion of credibility in the context of the digital information age is not different to that started in antiquity. From Aristotle's Rhetoric, it is the study of the method or art by which a provider of information is able to persuade one or more listeners of the truthfulness or correctness of his or her assertion. While referring the reader to the fascinating literature on the topic, we should perhaps only remind here the three means of persuasion, according to Aristotle [1857, chap. 2, pg. 12] (paraphrased from [Ramage and Bean, 1998]):

Logos the argument itself, its clarity and logic correctness.

Pathos the emotional state of hearer (not of the speaker).

Ethos the character of the speaker, his or her trustworthiness, authority, *credibility.*

Even if Ramage uses the term "credibility" only with respect to *Ethos*, the original text (as translated in English) states that the moral char-

acter of the speaker *"carries with it the most sovereign efficacy in making credible"*. We see here the distinction between the use of the term "credibility" with reference to the speaker (and therefore a synonym to "authority" and "trustworthiness") and the use of the term with reference to the message at hand (and therefore a mix of the three factors towards the degree of belief that the hearer or reader places on the message being conveyed). This distinction will be present throughout the present survey, even if the digital medium makes it occasionally more difficult than other media to identify correctly the author, or to make the distinction between authors, publishers, endorsers, or sponsors.

This study will be limited in the philosophical discussion of the meaning of terms like "credibility", "belief", "authority", "trust", or "trustworthiness". The terms have been used differently by different authors. Whenever possible we shall make observations on possible misuse of the terms in order to bring the various studies into the same working frame, but often it is impossible to tell whether the author really meant "credibility" or "trust". It will provide the reader with the set of most up-to-date references to get his or her research started in the area.

1.1 Motivation

According to a 2011 study [Pew Research Center, 2011], about 50% of computer literate individuals, with at least a college degree take *most* of the national and international news from the Web and the trend is increasing. That is: more than television, newspapers, radio, or magazines. It is therefore easy for the reader (as a member of the computer literate population addressed in the above mentioned study) to relate to the need for credibility on the Web.

A recent EuroStat report[1] shows that within the European Union (28 countries), in 2013, 75% of all individuals had used a search engine to find information. Certainly, these percentages are likely to drop in regions under development, but Internet penetration is on the rise even in the most remote places [Talbot, 2013, Pew Research Center, 2014]. In fact, it is likely that Internet adoption will outpace e-literacy [Wy-

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[1]`http://bit.ly/167xo82` Visited: August 2015, Most recent data: 2013

att, 2013], and at least some users will have the feeling of trying to quench their thirst for information from a fire hydrant. For instance, in the US, 90% of teens and young adults use the Internet [Lenhart et al., 2011], while only 83% of adults 18 to 24 have at least a high school degree [US Census, 2015]. In the case of the Web, this fire hydrant ejects an amorphous mix of useful, useless and malignant information. It is thus important to be able to differentiate good quality information in the mass of data available on the Web and an adequate understanding and/or modelling of credibility, under its different aspects, can be beneficial in this differentiation process.

This is by no means the first survey on the general topic of credibility. More on the side of communication studies, we have for instance Metzger et al. [2003], where the authors relate empowerment to the ability to determine the veracity of information in a technologically sophisticated context. The issue of youth and the digital media has been thoroughly explored in several studies, such as that of Flanagin and Metzger [2008a] and, more recently, Gasser et al. [2012]. The focus here is on communication studies, rather than the technology side. They include research on understanding users' mental models when assessing credibility, and on the development and evaluation of interventions to help people better judge online content. Moving slightly more towards technology, the field of captology [Fogg, 2003, Atkinson, 2006][2] studies how technology can be designed to persuade end-users. Much prior work in the area of credibility approaches the topic from a captology perspective, with a goal of understanding how people evaluate credibility so as, for instance, to help designers create websites that will appear more credible. Early examples include Shneiderman's [2000] guidelines for designing trust online and Ivory and Hearst's [2002] tool for high quality site design.

The current monograph complements and updates previous surveys: Golbeck [2006] and Lazar et al. [2007] examine the research literature in the area of Web credibility until the year 2007. They examine the general credibility of Web sites, online communication, such as e-

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[2]The term *captology* itself is a recent creation of B.J. Fogg, as a derivation on the acronym of *Computers As Persuasive Technology.*

mail and instant messaging and discuss the implications for multiple populations (users, Web developers, browser designers, and librarians). We expand this with the latest works on credibility in social media and, from a technical perspective, we are mainly interested in automatic methods used for credibility predictions.

A specific focus on trust on information and communication technology (ICT) infrastructures is observable in [Cofta, 2011]. This is something we will expand on as well, particularly since the focus here is on information retrieval, which implies a non-negligible amount of automated decision making that cannot be quantifiably verified in quite the same way as security protocols or network reliability can.

In fact, search engines play an undisputed vital role in the information seeking process and statistical semantic technologies play nowadays a very important role. In addition to topical relevance[3], they also use simple and efficient metrics to estimate the importance of a Web page (e.g., PageRank, HITS algorithms). A few observations can be made at this point:

1. PageRank-like algorithms are substituting a hard problem (credibility) by an easier problem (popularity) ;

2. there is the assumption that the search engine is an impartial information indexer with the users' best interests at heart. Even if that were the case for all search engines, the Web routes search results through a variety of intermediary nodes, most of the time without encryption; The negation of the assumption, as well as the existence of third party intermediaries puts into question the credibility we can assign to a search result list;

3. for the purposes of assessing credibility, the solutions to both of the above issues feed into a recursive credibility question unless the user can develop an understanding of the results provided.

Concerning system credibility, this survey will address primarily the first two problems, and only partially the third (particularly because

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[3]We include in topical relevance all methods potentially used to detect it: the variety of term-based matching methods, user click models, etc.

it includes a vast research area in Human-Computer Interaction). In doing so, we strive to focus on technical aspects employed by system developers in order to model, quantify, and assess the credibility of online digital content.

While works that tackle automatic credibility prediction for textual content already exist (and we shall cover them in the following sections), this survey will also specifically covers of credibility works in the multimedia domain. Visual content (images, but even more so videos) have the benefit of being their own proof. However, with complex image and video processing tools available on commodity, mobile hardware[4], making it significantly easier to alter visual content, this benefit will dissipate.

1.2   Definitions

Before proceeding, we should provide a definition of the two elements under discussion here: IR and credibility. In addition to definitions, the following two sections place the survey in context.

1.2.1   IR System

Figure 1.1 shows a highly schematized version of a retrieval system. The IR Engine itself may be considered to be only the *Ranking method*, which in this case includes the indexing, similarity scoring and any other components the retrieval system might have (e.g., relevance feedback). But there are other important components, particularly for the consideration of credibility:

1. Significant amount of information online is directly attributed to a person, be it the editor or author of an article, or the owner of a blog or twitter feed.

2. The data itself, generated by the above-mentioned user and to be indexed and made retrievable by the system.

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[4]At the moment of writing Dell was the only producer on the market with a tablet incorporating a light-field camera, while other manufacturers, such as Lytro or Raytrix had specialised cameras available to the general public.
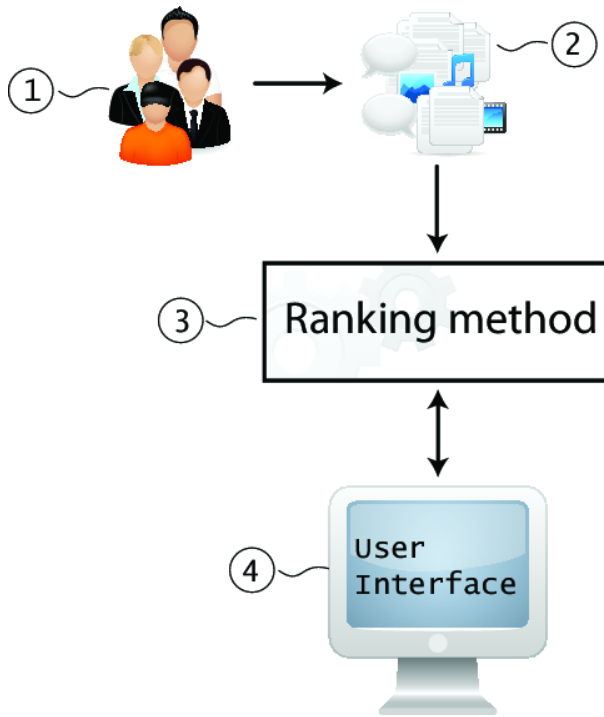
Figure 1.1: A typical information retrieval system.

3. The retrieval system itself that proposes a ranking of the documents available in its index.

4. The interface used to present results to the end-users and to provide interaction means with these results

   Information Retrieval is only part of the larger process of solving work tasks involving information that the user does not possess. The credibility requirements come from the work tasks rather then being intrinsic to the IR problem.
   Ingwersen and Järvelin [2005] discuss at length the common path that Information Seeking and Retrieval can and should take. Their view of information retrieval, deeply intertwined with the context in which it takes place, is depicted in Figure 1.2.
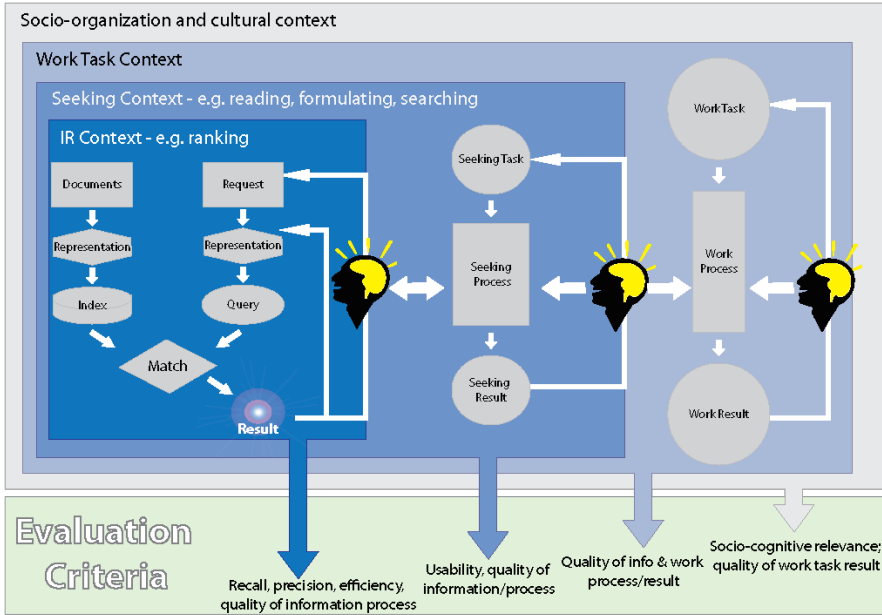
Figure 1.2: Information seeking contexts according to [Ingwersen and Järvelin, 2005].

In this general process, credibility is present in the seeking context. Credibility requirements come from the higher levels (organisation, work contexts) and the information identified in the IR context is first assessed for credibility in the Seeking process. We will further investigate credibility in the context of information seeking in Section 3 on Credibility Research Directions.

1.2.2 Credibility

We have already seen the eight definitions provided by various dictionaries for the term "credibility". Rather than attempting to add yet another definition to these eight, we will use this space to delineate the scope of the current survey.

Each of the four components in Figure 1.1 has its own role to play in the general assessment and study of credibility. This has been previously discussed and expressed as the difference between source, media,

and message credibility [Danielson, 2006, Rieh, 2010]. Throughout this survey we shall continue to observe, whenever possible, this distinction in the various studies at hand.

For the Web domain in particular and apparently for the source credibility only, Tseng and Fogg [1999] identify another four types of credibility:

- *Presumed credibility* is based on general assumptions in the users' mind (e.g., the trustworthiness of domain identifiers).

- *Surface credibility* is derived from inspection of a website, is often based on a first impression that a user has of a website, and is often influenced by how professional the website's design appears.

- *Earned credibility* refers to trust established over time, and is often influenced by a website's ease of use and its ability to consistently provide trustworthy information.

- *Reputed credibility* refers to third party opinions of the website, such as any certificates or awards the website has won.

We would argue that these can be filed even under the three classic components of persuasion: Pathos (Surface credibility), Ethos (Reputed and Presumed credibility), and Logos (Earned credibility) and therefore we will not use this specific distinction in this survey.

In terms of constituents of credibility, a majority of researchers agree to identify two components of credibility, namely trustworthiness and expertise [Fogg and Tseng, 1999]. However, we argue that because in today's digital media the source is so much harder to pinpoint [Sundar, 2008], two additional components are of particular interest in judging credibility: quality and reliability. Section 2 will go into significantly more details on each of these. In general, trustworthiness is understood as unbiased, truthful, well intentioned, while expertise is taken to mean knowledgeable, experienced, or competent. In addition, we will discuss quality, which is often seen as an intrinsic characteristic of content shared on the Web, and reliability, which refers to the extent to which something can be regarded as dependable and consistent.

Trust

However, before moving on to the components of credibility, we cannot end this introduction without relating credibility to trust. Trustworthiness, which we agree with the literature is a component of credibility, is a characteristic of the source or of the data. Trust is a characteristic of the consumer of the information and therefore much more related to the general idea of credibility. Therefore, before going on to the computer science aspects and uses of the term, we take a moment to very briefly put trust in the sociology context.

According to Kramer and Tyler [1996], there are at least 16 definitions of *trust* in the literature. The number of associated publications is a few orders of magnitude larger. This being the case, we make no claim to be able to cover even a small part of all these references. Nevertheless, we do need a starting point, and rather than attempting a definition, we prefer an example of the term's context, taken from popular culture[5]:

> "You can't trust Melanie but you can trust Melanie to be
> Melanie."   (Ordell Robie)

The term is used here as a verb, but it can easily be changed to a noun with the help of "having". The use in this context does not appear to refer to any particular property of the target of the trust (Melanie), but rather describes a state of the source (Ordell). This state may be described as *familiarity* of a particular situation or agent. Yet Luhmann [1988] cautions us to make the distinction between familiarity and trust: while trust can only be expressed in a familiar world, familiarity is a fact of life, whereas trust is a specific solution of problems of risk. Another way to describe Ordell's state upon issuing the statement above is *confidence.* In the scene, the character has an unmistakable confident attitude towards the situation, and towards Melanie. Yet again, Luhmann [1988] makes the distinction between trust and confidence: according to him, the first is the result of a conscious analysis of a target, while the second is to a large extent implicit and diffuse.

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[5]Ordell Robie is the character played by Samuel L. Jackson in Quentin Tarantino's 1997 film "Jackie Brown"

In fact, it would appear that for any particular definition, we would need to use some terms that are either creating a circular definition, or are somehow different. The first case is of course useless, while for the second we shall probably find someone providing a reasonable and well argued critique of why the new definition is essentially different from what we experience trust to be.

Therefore, another approach, taken among others by Ullmann-Margalit [2001], attempts to define trust by considering its apparent opposite: distrust. The problem is of course that trust and distrust are not defining the complete mental state of a person with respect to an agent: while trust implies the absence of distrust and vice-versa, it is neither the case that the absence of trust implies distrust, nor that the absence of distrust implies trust.

In his book, Deutsch [1973] analyses both trust and distrust from a psychological rather than sociological perspective, and proposes alternatives to viewing trust as confidence: trust can be despair (as the alternative of distrust), social conformity (perception of cowardness), innocence (from lack of information to cognitive defect), impulsiveness (exaggeration of benefits), virtue (related to social conformity), masochism (negative trust), or faith. This variety in definitions and perceptions led Metlay [1999] to state that attempting to provide a definition of trust conjures up former Justice Potter Stewart's oft-quoted reference to pornography—"it is something that cannot be defined precisely but one knows it when one sees it."

Trust and Knowledge

The general discussions about trust and trustworthiness, in sociology, psychology, or philosophy, are reflected in this survey only with respect to the transfer of knowledge. We mentioned in § 1.2.1 above that the focus here is Information Seeking, and Information Retrieval in particular, as methods and tools to answer an information need. Quite often these days, in both academic and non-academic life, the source of the information is separated from the consumer by the Internet. This is however not the essential difference to the time of book or print prevalence. The difference is that the information presented on the Web is

dynamic (may be there one day and changed or completely removed the day after), mediated by large sets of unknown agents (re-tweets, re-posts, blogs, aggregators, and recommenders), and, most differently, potentially *created* by large sets of unknown agents.

The view from § 1.2.1—of a consumer with an information need, to be satisfied from a source of knowledge—is now to some extent undermined because the consumer of knowledge is also the creator, and the simple act of searching becomes knowledge in itself (i.e., through log analysis, for instance). The link between trust and knowledge transfer grows therefore even stronger. Hardwig expressed it most acutely:

> Modern knowers cannot be independent and self-reliant, not even in their own fields of specialization. In most disciplines, those who do not trust cannot know; those who do not trust cannot have the best evidence for their beliefs. In an important sense, then, trust is often epistemologically even more basic than empirical data or logical arguments: the data and the argument are available only through trust. If the metaphor of foundation is still useful, the trustworthiness of members of epistemic communities is the ultimate foundation for much of our knowledge (Hardwig 1991).

In her PhD thesis, Simon [2010] addresses the topic of social knowledge creation (i.e., social epistemology) in the context of today's technologies for creating and sharing knowledge (i.e., socio-technical epistemic systems). Continuing the emphasis that Hardwig placed on trust in knowledge systems, Simon states that "for epistemic content to be considered trustworthy, we further have to trust non-human epistemic agents as well as the processes involved in the creation of this epistemic content". This is also our line of attack on the issue of credibility in information retrieval: addressing both the content and its creators, but also the systems and processes that bring us to this content. This is perhaps not fundamentally different from traditional media, but the peculiarities of the digital age, and most notably of the social web, multimedia abundance, and increasing reliance on machine learning and statistical semantics, provide the research with more than enough material to warrant a new view on the topic.

1.3 Structure of the survey

We start in Section 2 by defining each of the four concepts linked to credibility and provide arguments for our particular distinction between expertise, trust, quality, and reliability. Section 3 looks at general research trends related to credibility in information access systems, making the connection with information seeking research and provides details on features, algorithms, and output of credibility estimation efforts. The following sections address different aspects or perspectives, with the aim of helping the reader jump to areas of particular interest. Section 4 looks at particular domains, such as medical, blogs, or volunteered geographic information systems. In Section 5 we present the latest works on credibility in social networks, with a focus on Twitter and Community Question Answering platforms, while in Section 6, we cover an emerging line of research, namely credibility in the multimedia domain. Finally, the last Section talks about credibility of the information system itself, rather than the data and the sources, which are the primary focus of credibility research in the literature surveyed in the previous sections. After all the different methods and studies have been presented, Appendix A summarizes the existing resources that can be used for the assessment of credibility.

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