An Information Continuum Conjecture

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Abstract. Turing tersely mentioned a notion of "cultural search" while otherwise deeply engaged in the design and operations of one of the earliest computers.[1] His idea situated the individual squarely within a collaborative intellectual environment, but did he mean to suggest this in the form of a general information system? In the same writing Turing forecast mechanizations of proofs and outlined genetical searches, much later implemented in cellular automata. The conjecture explores the networked data-information-knowledge continuum as the subject of Turing's notions of search and intelligence, using analogous models from library systems theory. Floridi's philosophy of information is posed as a potential guide to applied information services design of the Turing type. The initial problem is to identify a minimal set of assumptions from Turing's essay beyond the general context of computing. This set will form a bridge to an analogous set of principles in library systems models by eliciting supporting evidence in the literature relating the two. Finally it will be shown how Floridi's philosophy of information more fully encompasses Turing's insight in view of the conjecture.

In a very interesting passage, Turing (1948) describes the idea of "cultural search" as a communal intellectual enterprise thus:

> "As I have mentioned, the isolated man does not develop any intellectual power. It is necessary for him to be **immersed in an environment** of other men, whose techniques he absorbs during the first twenty years of his life. He may then perhaps do a little research of his own and make a very few discoveries which are passed on to other men. From this point of view **the search for new techniques must be regarded as carried out by the human community as a whole**, rather than by individuals." [emphasis added]

About Turing's use of "techniques" we may speculate that at least the mathematical sense is intended. More generally, he poses "intellectual searches ... defined as searches carried out by brains for combinations with particular properties." Such a notion of "search" is distinct from syntactic string operations and is more like a query formulation. In today's parlance into this ontological category might be included the search engine, search agent, search bot and related combinatorial mechanisms and algorithms. As the essay concerns intelligent machinery, Turing implicitly defines intelligence in correlation to the efficiency of successful searching.[2]

We may assume he was not being trivial but imagined an information search in a qualitative sense: what routine pattern-matching, logical testing of combinations, evaluations of properties or other human procedures may be mechanized or automated such that learning and discovery may be optimized. How is the immersive environment of other minds to be interpreted given Turing's focus on the brain

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as a discrete state machine and the association of its finite states with definite, repeatable procedures performed by humans? Recall that in Turing's day no electronic store of digital information sources existed at all. Recorded knowledge was limited to traditional media and a typical content database was the compilation of technical specifications in massively paginated paper card sets. Turing seems to be treating computational content and program data as shared through logical arrangement, such as the storing of decision trees, "understandable" both to minds and machines. This intellectual environment is populated by information objects: data and logical structures, presumably of wide complexity and depth, constructively entered into memory and searched by humans for the broader purpose of the growth of knowledge, a communal goal.

The ultimate nature of "understandable" in this usage is obviously an open question. Also, this section of Turing's essay could be narrowly interpreted as a design document, per Churchman (1971), exacting more strict parameters for what might constitute unique philosophical systems of inquiry. This specificity is premature if we limit ourselves to Turing's general purpose machine as a vast memory store for the processing of data as well as instructions, accessible as readily as pages in a book, and in the prospective context of cultural heritage. Far from a wholly objective, inert and mechanistic conception of information, this system-equivalence of data and programming necessitates constant semantic interpretation. The extent to which memory of such decision-making may be systematically stored and its communication automated in this specific context of search should not compel an imposition of particular philosophical schemes of general inquiry. The question of *a priori* knowledge may also be left unresolved for the present. Turing's insight is to admit data and data structures, information and information structures, knowledge and knowledge structures as dynamical and logically interchangeable parts.

In this simplified discussion of search, the basic set of assumptions centers on the purpose of fresh learning from stored knowledge, together with the as yet unexhausted complement of techniques of inquiry concomitant with stored data/programming. As such the problem resembles the bare intersection of computing with the tradition of librarianship, but in digital form. As expressed by Kochen (1974) the main function of a library is "to maximize the greatest potentially attainable, effective, and efficient social utilization of documented knowledge, understanding and wisdom." General-purpose computing contributes the tools and methods for the digital aspect of the effort, which "shifts the burden on bibliographic control from keeping track of physical objects to intelligence." Mooers (1951) conceptually revolutionized our understanding of information storage as transmission through time, implying a necessary streaming or temporal component for stored objects, coining the phrase itself *information retrieval*. For three years prior to his essay on intelligent machinery, Turing concentrated his efforts on understanding real computer design and operations in England at the National Physical Laboratory's "Pilot ACE" (pilot project for an "Automatic Computing

Engine"). That design incorporated ultrasonic delay lines of liquid mercury serving as main memory. Physical pulses were introduced and converted to electrical signals under a strict time coordination in order to provide transactional, operational memory. It is interesting to consider this physical process as a manifestation of Mooers' conception and the subject matter of Turing's thinking. Its importance is that stored knowledge is transmitted knowledge, what was static is actually dynamic.

If Turing's search implied information storage and retrieval of the library kind, we should investigate this process as constructively loading the collective data and program store with the knowledge that it will also be dynamically searched. Some library models (Vickery, 1973) functionally simulate human information sources as aggregate entities connecting distinct units of knowledge through information objects (text or documents), mediated through augmenting processes which converge on an "informed" recipient in a coarse imitation of a mathematical communication channel linking sender and receiver by signals. A composite structure is indicated for the information elements of these graph models and each node interactively "searches" linked resources and transforms information through cybernetic feedback. The organizational context, the traditional role of the library as preserver of cultural heritage information, suffuses the individual user with a purposeful information environment or communication structure. Such context accords with an appreciation of the Turing notion of community search and presages a mathematical metaphysics of information. One implication of retrieval as storage, then, is abstraction of the informational nature of physical sources from their material bases for implementation as data plus logic; as transmission, the data sets and logic sets form combinatorial structures and mappings that are highly-interactive and dynamic in the manner of all human communications.

Other library models explicitly render complex computer-based information retrieval structures. Operational systems and programs put forth by mathematician Kochen (1966) have four core aspects in the shared intellectual environment: an information evaluation and synthesis tutor, including link-based multi-level markup, relational database, digital encyclopedia, and linguistic/logical analysis engines; bibliographic information control; current awareness, or an on-demand news and information service; and retrospective searching along the lines of present day internet search engines. Extension and abstraction of bibliographic information control in this manner seems a precursor to software ontological theory. Enterprise-level ontologies generate models of formal representation necessary to articulate the entities and activities within Kochen's most complex vision. The critical role of metadata[3] is as a tool to capture knowledge at the lower inter- and intra-aggregate levels of the service models, exemplifying an exchange-language of the new interactiveness: messages among ontological objects. Library theory of this complexity captures the notion of instruction about data in metadata. The earliest library systems succeeded in establishing communications by metadata itself, ahead of creating digital content and its direct exchange. This constitutes evidence of the attenuation of the traditional information object's physical nature. By manipulating descriptive "combinations with particular properties" in place of the physical information source, the intelligent or intellectual search treats instruction or logical description as data.

Library theory further traverses this path towards the virtual information object. The theoretical regard of information system services may differentiate to three key aspects (Lubetsky and Hayes, 1969): objectivity of a distinct intellectual product from the material record in which it is embodied; the consequence therefore of a thorough reconsideration of what is meant by authorship of that work; and, lastly, a recognition that information is organically embodied in the work rather than in the material as an isolated thing. Among the richest of library models, Kochen (1962) gives a notional outline for self-organizational digital concept processing in the form of a personal, query-answering information system to some extent parallel to Engelbart's overall program for augmentation of human intelligence from about the same time period. Kochen's representation of concepts within a machine begins with the assignment of signs to ideas and construction of a suitable well-defined language of such sign-combinations, beyond specific theorem-proving, searching, and pattern-recognition heuristics (Turing again), not so much machine-learning as the temporary external storage, processing, and retrieval of human learning. Kochen's mechanism would inductively form "beliefs" as a result of the continual adaptation of its machine representation of concepts due to human-submitted facts and queries. Engelbart from the beginning considers collaborative (cultural) systems. A complex Turing community search could be interpreted as a synthesis of the Kochen and Engelbart (1992) models. This broadening concept of an embedded "work" is consistent with the more recent object-oriented information model: concepts of work, expression, manifestation, agent, and action articulating a formal ontology of relations beyond bibliographic (Le Boeuf, 2001). Smiraglia (2002) has organized an extensive discussion of this concept of works as entities for information retrieval. Organic embodiment, of course, cuts both ways and is another facet of information dynamics as interactiveness: scholarly models considered to be works in an information system, such as scientific theories or epistemological schemes, may serve in turn as works considered to be models for other information services.

To restate the argument, the Turing essay suggests principles such as information as data plus logic, a varied structuring of both data and logic, an equivalence on-demand between these structures, and constructive loading of these into a storage-transmission system for the purposes of discovery and learning. A series of library system models suggest comparable notions in terms of the planned, selective and organized storage and transmission of cultural information, traditionally in books and printed matter, but with the emergence of computing tending towards an abstract yet still integral notion of content. A sense of technical vitalism would not seem misplaced, as where Von Foerster (1971) propounds information technology to librarians as a conceptual and not technological shift of emphasis from documents and books to the creation of knowledge. His key observation is that the user must have "direct access to the *semantic content*" of information sources [emphasis in original]. The book is for von Foerster, as for Floridi (1999), no longer the fundamental vehicle for knowledge acquisition, despite cultural identification with the printed word as "depository of all wisdom and knowledge." Knowledge acquisition depends upon a two-fold cognitive problem of the epistemology of autonomous information objects and the structure of semantic relationships as embodied in the organization of our brains, the whole acting as a system. "The world does not contain any information: the world is as it is; information about it is *created in an organism through its interaction* with this world." [emphasis added] Von Foerster takes as his anti-document the relational data base, not at all unlike Floridi's "calcified hypertext" and fully-tessellated infosphere. This reprise of organic embodiment firmly relates the desire for direct semantic access with a non-local view of "cognitive" systems. Giere (2002) drives this point home: "Rather than locating all the cognition in the human brain, one locates it in the system consisting of a human together with a [diagrammatic reasoning] diagram." This places the Turing conception of pattern-matching technique into the context of so-called cognitive information retrieval systems (Ingwersen, 2001), where the interactiveness of the continuum conjecture is seen as fundamentally between user and information object. In Giere's case this knowledge creation may be modeled in the form of distributed cognitive systems.

A final library model offered as evidence for the conjecture is the Functional Requirements for Bibliographic Records (FRBR)[4] data concept, relying on Chen's (1976) unified view of data in his seminal entity-relationship model, and employing notions of entities, actions and agents. Other semantic data models could suffice as well and complete the bridging process between the Turing search and library techniques. Ironically, the pedagogical method employed by a major survey (Peckham and Maryanski, 1988) of such models (for comparison purposes only) is an interpretation of a library system couched in database terminology. Smith (2003) reminds us of the pragmatic enterprise for these self-contained "truths" of software constructions: "It starts with conceptualizations, and goes from there to the description of corresponding domains of objects (also called 'concepts' or 'classes'), the latter being conceived as nothing more than nodes in or elements of data models devised with specific practical purposes in mind." Construction of information objects of the Turing search "type" could proceed similarly, from concepts and how they are structured in domains of knowledge in the form of data elements and models for learning and discovery.

How these practical purposes are considered in generalized information systems has also been the subject of philosophical investigation. These "intelligent" models are to be considered as parallel developments to the library systems models above. Sloman (1978) conceives of an intelligent mechanism or system containing a store of factual belief and knowledge, a philosophical if not technical sentiment following a long tradition from Leibniz through Bolzano and, as we have seen, Kochen. Is there also an echo of Turing's cultural search? Sloman cites the analogy of pre-computational bibliographic control in describing a particular role for information:

> In order that its contents be readily accessible, this store of beliefs will have to have an index or catalogue associated with it, possibly including general specifications of the *kinds* of information so far available or unavailable. For instance, it should be possible to tell that certain types of information are not present without exhaustive searches... The index may be implicit in the organisation of the store itself, like the bibliographies in books in a library, and unlike a library catalogue which is kept separate from the books. If books contained bibliographies which referred directly to locations in the library (e.g. using some internationally agreed system for shelf-numbers) the analogy would be even stronger.

The hypertext-transfer protocol, integrated online library systems, and digital object repositories have brought the analogy to an extremely strong form. The factual store and metadata store are encapsulated together in a kind of living, highly interacting information cell. This is still rather far off from notions of building conscious artifacts (Weyrauch, 1991) or, still further, artificial individuals, although the new digital objects pose significant problems as to persistence of an individual or entity through time, self-reference, modal logics and data structures. In the digital library of content and meta-content, the index and the catalog and the bibliography are *explicit* and the search readily accesses external references and discloses both information and lack of information depending on the results. Oddly, the library analogy crops up again and in light of the notion of Turing cultural search may represent a rich area for philosophical investigation. An example is the conceptual model of a generalized information system by Lynch (1997), bridging design factors between von Foerster's context-based organismic notions and Sloman's purpose-oriented polygenic treatment for factual information. Lynch combines several views helpful to the identification of a paradigm applicable to the Turing notion:

- A system attributes meanings to data in a context to a purpose
- Systems are intellectual constructs
- Information = data + human-defined meaning (though perhaps not exclusively)
- Core processes are unequivocally defined by human activity
- Decision = control at each hierarchical level
- Each logical consequence is recursive
- Data scaling and granularity are at issue
- Linking of individual epistemology with group ontology occurs

The last point seems to arise from the power of generalization in the conceptual model. Lynch's diagram, though distinctly not an architectural plan, at the same time can generate principles applicable both to organizational procedures for the handling of information as well as diagrammatic frameworks for individual operations.

The overall purpose of conserving cultural heritage information is one aspect of knowledge organization affording Turing's experience for immersion in works of other minds. The trend from physical to virtual may be found in library models of the fundamental units of scholarly exchange (Reinhardt, 1994; Buckland, 1997; Kircz, 2001, 2002) as this is particularly important in the area of digital preservation and design of systems which will effectively provide the same kind of reliable information services now available with print documents. If commodification amounts to an objectification of the artifact, in the case of intellectual artifacts is this a new ontological status for the information object? Does inherent interactiveness suggest a layered ontological interpretation? The Turing search object, a composite of data plus logic, could we not benefit from investigation of its metaphysical nature? From the physics of complexity, Steinhart (1998) expresses a digital metaphysics which describes programs as "orderings of abstract transformations of abstract states of affairs." To the extent that writing enables the storage of data or information, programming, it might be argued, affords general-purpose interaction with data or information. In the composite information object we find the active generation of diverse states of affairs, possibly characteristic of a search object and suggestive of internal information dynamics.

The philosophical models above do not focus on information itself as a philosophical subject. To explicate the relevance of Floridi having done so, the information continuum conjecture supposes Turing's insight to be coming to reality through the collaborative construction of software "search objects" in the form of intellectual artifacts preserving cultural heritage information. This information search ontology can be applied to the definition and design of special information system objects which simulate, emulate, replicate or otherwise reproduce works of scholarship, governance, research and other authoritative accounts controlling in certain domains of human activity, also known as self-contained digital objects. No judgment really need be made of the relative stasis of books and printer matter to similar forms extended to the digital realm. The non-digital forms serve as exemplars and a new appreciation of documentation, bibliography and librarianship emerges — print and physical storage is after all transmission through time.

Intellectual artifacts of the continuum conjecture are not necessarily dead, distributed relics of "rationalist" knowledge. Computational models of the information continuum often depict their own static structure: data at its base, an environmental resource, augmented by meaning at a layer of information, augmented by relevance, if not truth explicitly, at a layer of knowledge. Even in standards enjoying widespread though not universal consensus (JCS1-DoD/FED-STD-1037B/1992; ISO/ANSI X3.172-1990) data is considered to be the representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans *or by automatic means*; or any representation such as character or analog quantity to which meaning is *or might* *be* assigned; information is the *meaning* that a human assigns to data by means of the *known conventions* used in their representation. [emphasis added] Artificial Intelligence and Information Science (Howe, 1994) defines knowledge as "objects, concepts and relationships that are assumed to exist in some area of interest. A collection of knowledge, represented using some knowledge representation language is known as a knowledge base and a program for extending and/or querying a knowledge base is a knowledge-based system. Knowledge differs from data or information in that new knowledge may be created from existing knowledge using logical inference. If information is data plus meaning then knowledge is information plus processing." Sowa (2002) develops a knowledge extraction architecture in which logic graph algorithms serve as a unifying representation language, in the vein of Leibniz — the core of a dynamic interfacing between datalogical and infological aspects of a search object. The Turing community search is fully consistent with these later computational models of a data-information-knowledge continuum extending towards learning and knowledge discovery objectives.

Library, philosophical and computing models of the information continuum and information systems have in parallel articulated a realization of the Turning search as an information object itself. A newly conceived complex of information objects signals a revolution in terms of an extensive abstraction in the application of a constructive logic of classes to the status of the many information entities. In the case of librarianship, the 'computational turn' questioned the status of traditional physical objects of bibliographic control as the *raison d'etre* of the discipline. Questions debating the origins, importance, existence and ramifications of information objects span a complex lineage from an early "information transfer chain" (Weinberg, 1963) through the data-knowledge-information continuum to an extended "information object" (Davenport, 1992) information objects as an extended class of objects beyond the document as a physical surrogate of knowledge; "content object" (Renear et al., 1996) text ontologies, documents as hierarchies of content objects, a nesting of parts. Text itself is an ordered hierarchy of content objects, a natural unit based on meaning and communicative intentions; information modeling (Ashenhurst, 1996) ontological aspects; "meta-object" (Arms et al., 1997; Dovey, 1999) metadata objects aggregate digital objects; "boundary objects" (Albrechtsen and Jacob, 1998) in the form of classification and categorization systems; "smart objects" (Maly et al., 1999) known as buckets; digital object, such as a file designed for digital libraries where communication protocols are pushed down into data objects as methods in an object-oriented model and made "smarter"; Access methods, such as handles, address the modular internal contents of various packages of software, images and datasets; "knowledge object" or "objects of objects" (Veltman, 1999) metadata itself organized into an object; and an emerging panoply of meta-data objects, including a formal "learning object" (IEEE, 2002) perhaps the epitome of a Turing cultural search object. "Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning."

Librarianship has become increasingly attentive to root philosophical (Nitecki, 1998; Bonnevie, 2001; Budd, 2001; Blair, 2002; Hjørland, 2000) and theoretical (Nitecki, 1993, 1995, 1997; Cornelius, 2002; Capurro and Hjørland, 2003) subject matter in the last decade. However, no philosophy of librarianship or philosophy of information science informs the core of the subject matter, especially with respect to the information as a philosophical thing, until the appearance of the philosophy of information. Floridi's vision has the potential to serve as an instructional template in the application of the full bearing of traditional philosophical inquiry to the constructive pursuit that has been argued here in terms of building a Turing cultural search object system. Floridi (2003) gives an account for an 'information object' as not a material thing, but a Berkelean "mental entity" constituted by a Humean "bundle of properties." In an object-oriented ontological exposition these information objects are comprised of structured data plus program logic, which together interface with other objects via communicated messages. Floridi builds this model in order to show the operations and justifications for two theses in Information Ethics regarding information objects as moral agents and, more importantly, as possessing intrinsic worth. This is possibly a defining characteristic of the Turing cultural search technique. Floridi's information object also draws comparison with that of the Open Archival Information System (OAIS) Information Model[5], a typical and strong candidate for constructed intellectual artifacts. The OAIS information object is comprised of a data object whose interpretation is achieved "through the combination of the users' knowledge base and the representation information associated with the data object." These latter are syntactic and semantic information, themselves possibly in digital form. In the conceptual design environment, software objects are abstracted from real world objects following a recursive, structured analysis involving the flow of data; specified logic, action and ontology; and time-dependent behavior and dynamics. In the OAIS model, the knowledge base or ontology is external to the resulting representation network. Where all other elements of the information object are digital, the model may be grounded in a physical document for 'bootstrapping' the interpretation process.

Floridi calls attention to "problems that will become increasingly important the more the de-physicalized and digitalized our environment becomes." OAIS-type interactive information objects live squarely within this realm, de-physicalized when digitized (as the original ceases to "exist") and constantly dependent upon an online systems environment where grounding in a physical document may not pertain. Floridi's reasoning for the new philosophy of information does not depend upon syntactical, quantitative and semantic conceptualizations extant in mathematical information theory, in computational theory, in philosophies of language and mind, or in cognitive science. If the information continuum conjecture holds, then several sympathetic factors join together scholarship into the nature of information entities with the practice of providing information services. First, a constructionist perspective placing value in information as a fundamental entity should appeal to both a pragmatic epistemology and process-oriented philosophy associated with an information continuum purporting to address knowledge, its acquisition and the context of knowledge within cultures. Individuals construct intellectual artifacts both to express themselves as interactive spheres of experience as well as to actually relate to others of the same kind in order to effectuate change as social beings. Second, the interpretive capacity of such a theory recognizes the critical nature of the informing process and forces active construal of evidence by participants in that process. Third, many, most or all information system design theories lack an inherent ethical component. Floridi and Sanders (2003) demonstrate the significant possibility for advances beyond situated-agent and diagrammatic-reasoning approaches to the essentially dynamic creations of web-based information retrieval, clearly a concern on point for research on the information society. Fourth, the naturalization of process-products of the Floridian infosphere is evident already within theoretical considerations for fundamental revisions of the curricula in librarianship and information science or LIS (Williams, 1996).

Conclusion

Turing's cultural search may have anticipated the many and varied objects found along the data-information – knowledge continuum. An analogous theoretical dilemma in librarianship and information science today concerns digital preservation (transmission through human and machine generations) of the entire heritage of stored and born-digital cultural works of documented knowledge since Turing's essay. The task requires comprehensive planning and implementation across all sectors of the global information society while not being limited to any one discipline or philosophical system. In particular, unique difficulties arise because any original or prior physical object or context is not, is no longer, or will no longer be available at some place or point in time. This may be the essence of cultural evolution. The practice of "intelligence" in this endeavor consists of mainly the recognition, design and modeling of information systems and services whose purposes are interactive and collaborative, whose objects reside (perpetually regenerated) within the resulting dynamic interpretive environment and which involves special composite information objects themselves embodying the overall purposes and methods of knowledge. The wider program (Floridi, 2004) of philosophy of information far supercedes even the most comprehensive and universal information service, and so in diminutive form to Floridi's open problems are these suggested avenues of exploration in an applied philosophy of information:

Content

- What information objects are there?
- How do information objects behave?
- What are the foundations of LIS?

Meaning

- What data objects are there?
- What is authoritative; at what level?
- What is factual and authentic?
- Is there a semantic web? A pragmatic web?

Authorship

- What are intelligent documents?
- What protocols and standards?
- What are intelligent agents?
- What are the proper ontologies?
- Does information scale up to wisdom?
- Is data-information-knowledge continuous?
- Is LIS a social epistemology?

Community

- What is the scope of library information?
- Does librarianship create knowledge?
- Is universal access possible?

Ethics

- What ethical issues are unique to LIS?

Some of this work has already begun. Hjørland (1998) envisions a kind of artificial intelligence built into an information system linking subject specialists' knowledge of epistemological theory and semantics into "maps" of information structures. Users would then benefit from this disclosure of tacit and implicit frameworks of knowledge. Floridi (2002) has contributed to the discussions on social epistemology. The information continuum conjecture is intended to address a world of rich and copious cultural heritage and rapidly advancing technical means to explore the knowledge this legacy represents. The focus and purpose remains squarely on each individual child and adult and the enlightening and interpretive quality of a potential new experience upon each unique mind. In the tradition of learning must be the fresh re-discovery of what is re-presented by the learned as authoritative in the mind of the learning, not the mere tracing or following of past memories.

Notes

[1]**NPL and the ACE (1945–48)** [source: University of Manchester, http://www.computer50.org/mark1/turing.html#ace] Although Turing was not directly involved in the Colossus project, he knew what was going on. He saw the potential of the electronic computer to realise his long-standing dream of a machine that could carry out processes previously assumed achievable only by the human brain. He well understood that to turn it into a Universal Computer it needed the addition of a large electronic store which could store instruction codes as well as numbers. So in the last year or two of the war he learnt all he could about electronics, partly in connection with his Speech Secrecy project, and was rewarded when at the end of the war he was invited by

the National Physical Laboratory to design a computer. This he did by early 1946, designing the ACE around the only viable storage device perceived at the time, the Mercury Acoustic Delay Line. However, there were delays in starting to build his design, and Turing, disillusioned, was allowed to return to Cambridge for a "sabbatical" year (1947/48), returning to theoretical work and studying neurology and physiology. During the period that progress was stalled, Turing spent a lot of time on coding prospective routines, thinking about programming in general, and thinking about how the computer could be used to illuminate the mechanisms of the human mind.

[2]This suggestion and the notion of search as a new ontological category comes from the mathematician Witold Marciszewski in his introduction to a workshop *Strona güówna Warsztatów Turing 1998*. [http://www.calculemus.org/LogBank/Meetings/Turing98/index.html]
See his essay "On A.M. Turing's *Intelligent Machinery, 1948: Quotations and Comments*" [http://www.calculemus.org/forum/1/tur-com1.html]

[3]**Metadata**. Data about a data file. For example, if an online journal article is the primary data file, then its metadata could include the author, title, publisher, date, and URL. Different metadata standards put different elements in this list and sometimes identify the same element by different names. For example, for some purposes the language, copyright owner, classification number, or "family safety" rating, would be relevant, while for others they would not. Metadata can be used to help locate documents, catalogue them, preserve them, navigate among them, open or block access to them for certain users, and link citations to sources. Because the metadata file is almost always smaller than the corresponding data file, it can greatly speed up processing where it can stand in the place of the data file, e.g., for searching or cataloging. In the industry jargon, information sources "declare" or "expose" metadata, while information services like search engines "harvest" the metadata. The list of elements in a metadata file is a "vocabulary" and the formal definition of a vocabulary is a "schema". Source: Suber, Peter. Guide to the Free Online Scholarship Movement. http://www.earlham.edu/~peters/fos/guide.htm#metadata

[4]See: Functional Requirements for Bibliographic Records Final Report (UBCIM Publications — New Series Vol. 19) International Federation of Library Associations and Institutions. IFLA Study Group on the Functional Requirements for Bibliographic Records, Approved by the Standing Committee of the IFLA Section on Cataloguing (September 1997) K.G. Saur München 1998
http://www.ifla.org/VII/s13/frbr/frbr.htm

[5]An early formulation contained in "Preservation Metadata for Digital Objects: A Review of the State of the Art" A White Paper by the OCLC/RLG Working Group on Preservation Metadata, 31 January, 2001. http://www.oclc.org/research/pmwg/presmeta_wp.pdf

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