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Future Directions for Semantic Web Technology

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Abstract
Numerous fields have shown interest in the semantic web and its technology. They are able to consistently and logically link and arrange data over the internet. Semantic web technologies, which include OWL, RDF schema, and rule and query languages like SPARQL, will aid in the problem-solving of diverse areas. The first part of this review paper examines the requirements and nature of the semantic web. All ten domains that are closely related to the semantic web and its technologies have been taken into consideration. We have divided the paper into three main contributions for easier comprehension. Initially, we examine the semantic web and the domains that contribute to its expansion. Second, we talk about every domain.
KEYWORDS: *Semantic Web, OWL, SPARQL, linked data, ontology*

I. Introduction

The Semantic Web means sharing data and facts rather thansharingthetextofapage.ThethoughtofaSemanticWebwasgivenbySirTimBerners-Leein2001.TheSemanticwebhelpsbuildatechnologystacktosupporta'webofdata'ratherthana'webofdocuments.'Thefinalaimofthewebofdataistopro-videcapacitytothecomputertodomoremeaningfultasksandto develop systems that can support trusted interactions over the network. Semantic web technologies (SWTs) include differentdatainterchangeformats(e.g.Turtle,RDF/XML,N3,N-Triples), query languages (SPARQL, DL query), ontologies, and notations such as RDF Schema and Web Ontology Language(OWL), all of which are intended to bestow a formal description of entities and correspondences within a given knowledgedomain.Thesetechnologiesarehelpfulforachievingtheover-all objective of the semantic web. The heart of the semantic web is the linked data because linked data provide large-scale data integration and reasoning on the data.Linked data become powerful by technologies such as SPARQL, RDF, OWL, and SKOS, but there are also many challenges for linked data which are described by various papers. Ontologies are the back bone for structuring linked data and play a major role in defining links within a dataset and across datasets to other linked data. They enable users to search a schematic model of all data within the applications. By using ontology we can combine deep domain knowledge and raw data and bridge datasets across domains. Ontologies are efforts to more precisely classify parts of the data and to permit communications between the data available in distinct formats. The universal standard for communicating ontologies and data on the Semantic Web is web ontology language.

Thedatabaseisnotopenlysuitableintheareaofthesemanticwebbecauseitholdsadissimilardatamodel.Mostdatabasebench-marks are designed in the direction of a relational data model. The mathematical idea behind the relational data model is theset theory which is a part of the Cartesian product. The web ontology language data model, on the opposite hand,gives a lot of adaptability. The resource description framework (RDF) is based on the idea of graph theory. Furthermore, web ontology language is based on description logic; it includes description logic (DL) expressions and axioms or restriction. Knowledgegraphisalsoanessentialcomponentforthesemanticweb.Theterm'KnowledgeGraph'wascoinedbyGooglein2012andisintendedforanygraph-basedknowledge.Therearemanytypesof knowledge graph available such as DB , Freebase, Wikidata, YAGO and so on. Ultimately, comprehensiveknowledge bases like DBPEDIA and WIKIDATA play an essential role in dealing with the problem of information overload.The thought of acquainting semantics to quest on the Web isnot clear in an exclusive manner. Other factors like scalability,availabilityofcontent,visualization,ontologydevelopmentandevolution, and multilingualism and stability of semantic weblanguagesarethemajorchallengesforthesemanticweb,whichprovides directions for the researcher. The two most ordinarybehaviors of semantic web technologies are (1) to understandWeb queries and Web resources annotated along with back-groundknowledgedefinedbyontologiesand(2)tolookintotheorganized huge datasets and knowledge bases of the semanticwebasanoptionorcomplementtothepresentweb.Thevastapplications of semantic web technologies make possible theprovision of benefits to other domains such as sensor network,bigdata,cloudcomputing,Internetofthings,andsoon.

II. Review of related works

Manyauthorshavepresentedsurveysaboutthedomainsrelatedto the semantic web, but most of them pick one domain anddiscuss how that domain relates to semantic web technologiesand define all the aspects of that domain. At the end of thepaper, they conclude how they resolved the problems of thesemantic web by using that domain. In this section, we dis-cuss all the related surveys on the semantic web and its relateddomains and lastly explore how the art of our survey is different from existing surveys. Many researchers have played avitalroleinthefieldofthesemanticweb.Bittencourt [1] have described some major research directions for semantic web and education. They have opined that the use of thesemantic web in education systems can help in the achievement of 'Anytime, Anywhere, Anybody Learning' because itusestheconceptofontologieswhichprovideinformationina computer-understandable manner. The arrival of semanticwebtechnologiesintourisminformationsystemsfacilitatesthemanagement and interoperation of semantically diverse dataandprovidesaccurateandflexibleinformation.Markellouetal [2] haveproposedaframeworkforpersonalizede-Learningon the basis of aggregate usage profiles and domain ontology.Thewholeprocessisdividedintotwostages:offlinestage(datapreparation, ontology creation, and usage mining) and onlinestage (production of recommendations). Semantic web technologies such as RDF, ontologies, and OWL provide flexiblerepresentation of knowledge. These technologies are used ingeographical information systems for searching and classifying feature. Some authors have used the concept of semanticweb technologies for the earthquake recommendation system.Theyhavestoredearthquake-relatedinformationintoontologyandthenprovidedinferenceoveritbyusingSPARQLqueries. Kenekayoro[3]haspresentedthefutureofthesemanticwebbyreviewingthetechnologiesofthetraditionalweb,semantic web,and their areas of application. He has pointed out that migration from the current web to the semantic web is a particularlyslow process because publishing data for the semantic web isnotassimpleaspublishinginHTML.Themainproblemisnotonly accessing and processing information, but also extractingand interpreting. By using ontologies and intelligent services,we can transform the web of information into the semanticweb . Bizeretal.[4]haveexplainedtheprogressofthelinkeddataonthewebalongwiththeirapplications.Theyprovideguidelinesfortheresearcherandillustratedifferentmethodsforpublishingthedataontheweb.Encoding,publishing,andinterlinkingbetweendataareanexampleoflinkeddatathatcanbeobtainedfromsemistructuredsources.Bizeretal.haveexplainedtheproblemsrelatedtotheimplementationofthegloballinkeddataandnontechnicalbarrierstotheimplementationofweb 3.0.Harthetal.[5]havewrittenachapteronlinkeddataandthestandardsofthesemanticweb. They have explained all the steps of the semantic web stack and provided a comprehensive overview about RDF terms, triples, graphs, vocabulary, syntax, query clause, etc. Semantic approaches arrange all the data over the web in a regimented way. They represent a method by which we map the data over the web via ontology and then access the data through an agent. By using semantic web technologies, we access domain knowledge easily, and semantic annotation is an important step for data mining. Kumar [6] has argued that interoperability among applications is a complex issue. He has described how best we can employ SWTs to accomplish interoperability and security issue among applications. Some authors have presented a study for social network analysis by using big data and semantic web technologies. Social networking services like Facebook deal with huge amounts of dissimilar data that act as an input for social net- work analysis by researchers. The main aim of their analysis is summarization of all techniques and challenges along with research directions that exist in social network analysis. Various authors have offered an exhaustive survey of the Semantic Web in the fields of Data Mining and Knowledge Discovery along with an outline of semantic web approaches in different platforms of the knowledge discovery process. Dhenakaran and Yasodha [7] have presented a review paper on semantic web mining. The target of these authors is to provide a sketch of web mining, its classifications, and its subtasks and present their point of view to the research community about the potential of applying techniques to mine meaningful patterns. They have additionally provided a study of the recent works and compared traditional web applications with semantic web applications and presented a direction for future research in the field of semantic web mining. Some authors have also provided all ongoing research in semantic web mining and pointed out the obstacles faced by the researcher. Stumme et al. [8] have presented a review paper and potential guidelines for semantic web mining. They have provided scenarios where semantic web mining will take place and inferred how the semantic web can enhance the consequences of web mining. Many researchers have focused on mapping between relational databases to RDF and defined reference architecture. Authors have analyzed all the approaches of semantic web and web mining areas and finally discussed all the mining tools. Sridevi and UmaRani Huang et al. [9] have used an artificial neural network approach and proposed a new algorithm for ontology match- ing. They have avoided the existing problems of rule-based and learning based matching algorithms of biological ontologies. Caliusco and Stegmayer [10] have presenteda chapter on 'SWTs and Artificial Neural Networks for Web information Source detection.' They have described the advantages of integrating Artificial Neural Networks (ANNs) and SWTs. Chen et al. [11] have discussed the point that semantic web accommodates computational intelligence (CI) which adds Evolutionary Computation (EC), fuzzy logic, and ANN. They have said that we can use Supervised ANNs for Ontology Alignment and Unsupervised

ANNs for Ontology Learning. The fuzzy logics are helpful in improving query results in the Semantic Web. Yu and Chen [12] have offered a survey on web scale semantic information processing for cloud computing. They have presented a summary of existing technologies for semantic information processing in a cloud computing environment and described parallel process- ing, storage, query, and reasoning. The challenges of cloud computing can be overcome by semantic web technologies. Sheth and Ranabahu [13] have discussed those areas where semantic models can support cloud computing. They have described that semantic models can work in three dimensions of cloud computing, namely data modeling, functional and nonfunctional definitions, and service descriptionenhancement.Androcecetal.[14]havepresentedareviewpaperoncloudcomputing ontologies and their applications. They have summarizedtheselectedstudiesintofourmaincategories:Cloudinteroperability,Cloudservicesdiscoveryandselection ,Cloudsecurity,and Cloud resources and service description. At the end of thepaper, they have given research directions including those thatare closely related to the security and interoperability of CloudComputingofferings. Kotis and Katasonov [15] have written a paper on ‘SemanticInteroperabilityonthewebofThings(WoT)’andproposedontologylearningandalignmentmethods.Theyhavespecifiedtherequirementsofsemanticregistration,coordination,andtheretrievalofthings.Zengetal.[16]havepresentedareviewpaperontheWoTanddiscussedadetailedarchitectureandsomekeyenabling technologies of the ‘WoT’ along with recent researchresults.Theyhavepointedoutsomeopenchallengingissuesin this field. Kotis and Katasonov [17] have offered a paper on‘Semantic Interoperability on the Internet of Things (IoT)’ andpresented a use case diagram for the alignment of entity. TheyhaveopinedthatontologyisthekeycomponentfortheabstractionandsemanticregistrationofIoTentities.Zafeiropoulosetal.[18]havereviewedallthetechniquesofdatagatheringin the sensor network and provided three layers of architecture for this process. This architecture deals with many problems such as data aggregation, data management, and queryansweringbyusingsemanticwebtechnologies. Comptonetal.[19]havedescribedoneoftheessentialtechnologies in the semantic sensor network, called ‘semanticspecificationofsensors.’Twelvesensorontologies,andreasoningandsearchtechnologydevelopedinconjunctionwiththeseontologies,arereviewedandanalyzedforpointingouttherangeandexpressivepoweroftheirconcepts.

III. Semantic web and technologies

TheSemanticWeb,whichisanextendedversionofthecur- rentweb,providesastandardstructurefordatarepresentationandreasoning.Heredataarestoredintheformofontologiesthatprovideinferencepoweroverthestoreddata.Thesedaysthewebisusedforthreemajorimportanttasks,i.e.Searching, Combiningofdata,andMiningofdata.Theefficiencyoftasksheavilyreliesonthestorageandrepresentationoftheknowledgestructure.Therefore,variousknowledgerepresentationschemesandlanguageshavebeendevelopedinsuch awaythatnopartofknowledgeinthesaiddomainremainsuncovered.TheSemanticwebusestheconceptoftextminingfor betterdataprocessingoftherawdatathatexistonthewebintheformofXMLandRDF.TheextractionofMetadataisoftwotypes:explicit metadata extraction and implicit metadata extraction.The implicit Meta data extraction implicates semantic informationdeducedfromthematerialitself,forexample,nameof entity and associations enclosed in the text. This processessentially takes the help of ontology. Traditional informationextraction is based on a flat structure, but we need informationinahierarchicalstructurefortheSemanticWebbecauseweconnect semantic metadata along with documents and address theconceptsintheontology.

IV. Towardthegrowthofthesemanticweb

TheSemanticWebdataspaceisdistributed,dynamic,incoherent,andverysensitivetoprivacyissues.Therearethreedomains thathelpinfurtheringthegrowthofthesemanticweb.ThefirstdomainiscomputationalIntelligence,thesecondoneisEvolutionaryandSwarmComputing,andthelastisknowledgerepresentationmethods.Withthehelpofswarmcomputingwestorelarge- scaledataandprovidereasoningovertheweb.Computationalintelligenceprovidesthemethodsforhandlingvaguenessanduncertaintyissues.Knowledgerepresentationmethodshelpstorethedatainaconsistentandcoherentmanner.

4.1 Computationalintelligence(CI)

CIisasetofmethodsthatmainlyconsistsofEvolutionaryComputation,FuzzyLogic,andANNs.TheSemanticwebhasmanyproblems because of vast, incomplete, uncertain, inconsistent,anddecentralizedinformation.AvarietyofCImethodsareusedtocracktheissuesofthesemanticweb.Wereviewtheseissuesfrom three aspects, where different CI techniques have beenused.ThefirstisVastnessandTractability,thesecondisVague-ness and Uncertainty, and the third is Divergence and Inconsistence. Researchers use evolutionary computation in case oftractability and vastness issues. The fuzzy logic system is useful for solving the problems of uncertainty and vagueness inWebsemantics.ANNsarewidelyusedforsolvingtheproblemof inconsistency in data mapping and alignment. ANNs takethe advantage of structural and functional views of biologicalneural networks. They provide a way by which we extract hid-den correspondences or patterns from large amounts of data..

4.2 Evolutionaryandswarmcomputing

Evolutionary and swarm algorithms are used for optimizationproblemswithalargeanddynamicsearchspace.Semanticwebapplicationsrequirescalable,adaptive,andvigorousapproachesto store and examine large-scale data. The solution to thisproblem is to dispense both data and requests onto variouscomputers. Along with storage, the annotation of data withmachine-understandable semantics is also very vital for under-standing the idea of the semantic web. Reasoning and storageover the web entails the same requirements; therefore, we usetheevolutionaryapproachesforqueryingandswarmalgorithmforentailment.Swarm-basedtechniqueshavebeenrevealedto generate optimal solutions for critical issues in an entirelydecentralized manner. We utilize a new concept for reasoninginsideanentirelyspreadandself-organizedstoragesystemthatisrootedinthecollectivebehaviorofswarminstancesanddoesnot want any schema replication.

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4.3 Knowledgerepresentationofsmarterdata

Amajoraspectofthedevelopmentofanystructureorapplications heavily depends upon the representation scheme.Agoodschemethatdescribestheunitofknowledgeisthemostinevitablerequirementofthetime.ExtendedHierarchicalCen-sored Production Rules (EHCPR), can be used to represent thedomain knowledge because it handles problems related to representation,learning,andreasoning.ThestructureofEHCPRvisualizes real-world entities in an effective manner. It has thecapacity to store and manage large amounts of data with thehelp of constraints and default values of entities. Here, proper-ties are divided into two parts, namely defining property andcharacteristicproperty.Foranindividual,thedefiningpropertyof a concept must be true, whereas characteristic property mayor may not be true. The structure of EHCPR is divided intotwo parts: knowledge base (storage of concept) and databases(storage of instances). The sequence of class is described bygeneralityandspecificityoperators.

V. Domainsrelatedtosemanticwebtechnologies(SWTs)

SemanticWebtechnologiesinvolvemanyareasofcomputerscienceandhaveresolvedmanyissuesregardingtherepresentationand extraction of information. In this section, we mention fivedomainsthatarecloselyrelatedtosemanticwebtechnologies.

5.1 Sensornetwork

Sensor networks are utilized in many areas for capturing physicalnaturaleventsandobservethecharacteristicsofphysicalobjectsliketemperature,sound,pressure,andsoon.A sensor network produces a huge amount of data that requireenhanced logical processing and interpretation by machines.Sensornetworkshavegeneratedalotofinteresttodayinacademiaaswellasindustry.Theyareanewparadigmfordistributedsensingandactuation.Themajorchallengesinthisfieldarecoverage,connectivity,andclusteringinheterogeneoussensor networks, deployment strategies and topology or neighbor discovery techniques, localization algorithms, secure dataaggregation, energy optimization, and the security and quality of services. In real-world application, sensor data will be amix of dissimilar data that come from various networks. Theprocessing and interpretation of the vast amount of unstructured sensor data and the utilization of a consistent structurefor this sensor data are a crucial part of scalable and interoperablesensornetworkarchitecture

5.2 Cloudcomputing

Cloud computing is an extended form of Internet-based computing that provides shared resources of computer processinganddatatocomputersandotherdevicesondemand.Itdeliverscomputingserviceslikesoftware,servers,networking,storage,and so on over the Internet. Cloud computing is a very vastarea for research; therefore, the landscape of cloud computinghas significantly changed over the last decade. The most challengingresearchdirectionsforcloudcomputingarestorageandfault tolerance strategies, peer-to-peer-based cloud workflowsystem,adaptiveanddata-drivenworkloadmanagerforgeneralclouds, service scalability and interoperability over the cloud,thecombiningofhigh-performancecomputingintocloudcomputingservices,scientificservicesanddatamanagementinthecloud, and cloud computing privacy and security preservationin the cloud. We can remove problems of cloud interoperability by storing the information of cloud Resources and ServicesDescriptionintoontologieswithfivemainlayers,namelysoftware infrastructure, software environments, software kernel,hardware,andapplications.Eachlayerholdsmorethanoneservice ifit hassimilar levelsof abstraction.The cloudsystem forservicediscoveryusestheconceptofcloudontologytocomputethecorrespondencesamongtheservices.Thissystemis anagentbaseddiscoverysystemthatutilizesthreetypesofsimilarreasoningandenablestoobtainthecorrespondencesofcloudservices.Theircloudontologyhasentitiesofdifferentcloudser-vicesforinfrastructureasaservice,softwareasaservice,andplatformasaservice.Cloudcomputingontologiesaremainly usedfortheselectionanddiscoveryofthebestserviceaccordingto users' needs and the description of cloud services resources.

5.3 Bigdata

'BigData'isatermthathasbeenusedtoexplainalargeamountof data that have been generated over the last 20 years. Face-book, Twitter, and other social media not only create a lot ofdata;theyadditionallymakeitfeasiblefordeveloperstoaccess.There are many problems in organizing the data that emanatefrom various sources and in various formats. Various authorshavewrittenreviewpapersonthefuturechallengesofbigdata.Someofthechallengingfutureresearchguidelinesforbigdataare Scalable Architectures for Massively Parallel Data Processingand Stream Data Processing, Scalable Storage Systems, Security and Privacy Issues in Big Data, Large Scale Data Analysisfor Social Networks, Privacy Preserving Big Data Analytics andAdaptation, Big Data Analytics for Business Intelligence andSmart Healthcare, Uncertain Data Management in Big Data,and Big Data Visualization and Semantics. Among them 'BigData Analytics' has become the center point of research. Oneof the real issues for Big Data Analytics development is thediversity of web-based information because the collected dataareunstructuredinnature.Thisiswhere'SemanticWebTechnologies' come into the picture. The international communityW3C has encouraged a common data format to make the dataon the web more reliable and easier to interpret. For Big DataAnalytics-basedorganizations,SWTsassisttheminbusinessesenabling then in making an even better judgment in real time.For business to consumer organizations (led by Google), thesemantic web permits them to offer consumers with superioranswersandexperiencesimmediately.Theapproachtoaddresstheproblemthatisconnectedwithbigdataistostoredatainastructuredformatandcharacterizethedatasetsasgraphs. Thispermitssoftwareagentstoqueryonthedatabases.Theprocessingoflinkeddatamakesitfeasibletofindinformation. Aknowledgegraphisagoodexampleofbigdataonthesemanticweb.ThisknowledgegraphwasaddedinGooglein2012–2013andprovidesanupdatedalgorithmcalled'Hummingbird.'

5.4 InternetofThings(IoT)

The IoT has required semantic backbone to thrive. More than25billiondeviceswereestimatedtobeconnectedtotheInternetin2015and50billionby2020.Theinteroperabilityamongthethings on the IoT 'is one of the most essential requirements tosupportobjectdiscovery,addressingandtrackinginadditiontoinformationstorage,Security,representationandexchange.'IoTwill essentially comprise different sets of devices and differentcommunicationstrategiesbetweenthedevices.Thistypeofheterogeneous system should evolve into an additional organizedset of solutions, where 'things' are made consistently discoverable, empowered to communicate with different entities, andare strongly included with Internet infrastructure and services,insteadoftheparticularwayinwhichtheyareassociatedtotheIoT.Dynamicity,diversity,networks,data,andtheheterogeneityofdevicesarekeyissuesofIoTtechnologies.Semanticwebtechnologieshavebeenprovedfruitfulindifferentareasindealingwiththeheterogeneityissuein(i)interconnectingsuchdata(ii)inferringnovelknowledgeindevelopingintelligentapplications(iii)providinginteroperabilityindatamanagement.How-ever,oneofthechallengeswithexistingIoTapplicationsisthatthedevicesarenot(orlittle)compatiblewitheachotherbecausetheirdataaredependentonproprietaryformatsandtheydonotemploycommonvocabularytoexplaincompatibleIoTdata.SWTshavealreadyshowntheirbenefitsindomainsotherthanIoT. Semantic web technologies are used in IoT to reduce thechallenge in dealing with interoperability of data produced bydevicesalreadyemployedinreallife.TheSemanticWebdealswithIoTandWoT.Uponrealizingthetruepotentialofsemantic technologies, various IoT frameworks have been proposedwhich address the data interoperability issues using SWTs andstandards.For the development of the IoT, many semantic technologiessuchasontologies,semanticannotation,RDF,linkeddata,semanticwebservice,andsooncanbeusedasaprincipalsolution. The use of ontology with a semantic description for datawillmakeitinteroperableforclientswhoshareandutilizethe same ontology. Through semantic technologies in IoT, we canhandle interoperability, efficient data processing, resource discovery,integration,reasoning,andquerying.

5.5 Miningandanalytics

Nowadays,asahugeamountofinformationisavailableonthe web, more than one billion pages are indexed via searchengines, and therefore, searching for the desired information isanextremelytrickytask.Thisrichnessofresourceshasencouraged the requirement for developing automatic mining techniques on the World Wide Web, thus giving rise to the term'Web Mining.' SWTs intend to address the issue of extractinginformation from the web by offering machine-understandablesemantics to give better machine support for the client. Anintegrated approach of SWTs and web mining provides a better method for the mining of related and semantic informationfromtheweb,thusgivingrisetotheterm‘SemanticWebMining. The combination of SWTs and web mining enhances theconsequences of web mining through utilizing the semanticstructure in the web. Ontology has the capacity to mine datafrom a large pool of data. It is used during preprocessing forimproving clustering results. SWTs make Web mining simplertoaccomplishandcanalsoenhancetheefficiencyoftheprocess.Byusingsemanticwebtechnologieswithlinkedo pendata,wesupportknowledgediscovery.

VI. Discussion and conclusion

The paper is structured into five sections, namely Introduction, Review of related works, Semantic web and Technologies, Toward the growth of Semantic Web (ComputationalIntelligence, Evolutionary and Swarm Computing, KnowledgeRepresentation of Smarter Data), Domains related to Semantic Web Technologies (Sensor network, cloud computing, Bigdata,InternetofThings,MiningandAnalytics),andHowother domains go hand in hand with Semantic Web (MachineLearning, Natural Language Processing). Art of review differsfrom other reviews in three key areas: first, we present thosedomains that enhance the growth of semantic web, secondlywe explain all domains that utilize the semantic web technologies,andthird,wementionthosedomainsthatgohandin hand with semantic web technologies. This paper providesanswers to various questions like Can SWTs be applied in differentfields?,HowSWTsarehelpfulforotherdomains?,Howother domains enhance the progress of semantic web?, Whatare the research directions for the semantic web and its relateddomains?, Why and how SWTs are important?, Which type ofKnowledgeRepresentationlanguagesareusedbytheSemanticWeb?, Which type of problems require immediate attention ofthe researchers?, How can we reduce the existing issues of theSemanticwebwiththehelpofotherdomains?,Whatisthecur-rent progress of the Semantic Web? and so on. To the best ofour knowledge, it is a first attempt to bring all domains relatedtoSWTsintooneplatform.

References

[1] BittencourtII,IsotaniS,CostaE,etal.Researchdirectionsonsemanticwebandeducation.InterdisciplStudComputSci.2008;19(1):60–67.
[2] Markellou P, Mousourouli I, Spiros S, et al. Using semantic webminingtechnologiesforpersonalizede-learningexperiences.In:Pro-ceedingsoftheweb-basededucation;2005.p.461–826.
[3] Kenekayoro PT. Semantic web-the future of the web. Afr J MathComputSciRes.2011;4(3):113–116.
[4] AbaalkhailR,GuthierB,AlharthiR,etal.Surveyonontologiesfor affective states and their influences. Semant Web. 2018;9(4):441–458.
[5] Bizer C, Heath T, Berners-Lee T. Linked data: the story so far. In:Semantic services, interoperability and web applications: emergingconcepts.Hershey(PA):IGIGlobal;2011.p.205–227.
[6] HarthA,HoseK,SchenkelR.Linkeddata&thesemanticwebstan-dards. In: Linked data management. Chapman and Hall; 2016. p.28–73.
[7] KumarVK.Semanticwebapproachtowardsinteroperabilityandpri-vacy issues in social networks. Int J Web Serv Comput. 2014;5(3):13–17.
[8] DhenakaranSS,YasodhaS.Semanticwebmining:acriticalreview.IntJComputSciInfTechnol.2011;2(5):2258–2261.
[9] StummeG,HothoA,BerendtB.Semanticwebmining:stateoftheartandfuturedirections. JWebSemant.2006;4(2):124–143.
[10] Sridevi K, UmaRani DR. A survey of semantic based solutions to webmining.IntJEmergTrendTechnolComputSci.2012;1:50–57.
[11] Berendt B, Hotho A, Mladenic D, et al. A roadmap for web mining:from web to semantic web. In: Web mining: from web to semanticweb.Berlin:Springer;2004.p.1–22.
[12] Huang J, Dang J, Huhns MN, et al. Use artificial neural network toalignbiologicalontologies.BMCGenomics.2008;9(2):S16.
[13] CaliuscoML,StegmayerG.Semanticwebtechnologiesandartificialneural networks for intelligent web knowledge source discovery. In:Emergentwebintelligence:advancedsemantictechnologies.London:Springer;2010.p.17–36.
[14] Chen H, Wu Z, Cudre-Mauroux P. Semantic web meets computa-tional intelligence: state of the art and perspectives. IEEE ComputIntellM.2012;7(2):67–74.
[15] Yu W, Chen J. The state-of-the-art in web-scale semantic informa-tionprocessingforcloudcomputing.arXivpreprintarXiv:1305.4228.2013.
[16] ShethA,RanabahuA.Semanticmodelingforcloudcomputing,part 2.IEEEInternetComput.2010;14(4):81–84.
[17] AndrocecD,VrcekN,SevaJ.Cloudcomputingontologies:asystem-aticreview.In:Proc.ofMOPAS;2012.
[18] Kotis K, Katasonov A. Semantic interoperability on the internet ofthings:thesemanticsmartgatewayframework.IntJDistrSystTech-nol.2013;4(3):47–69.
[19] ZengD,GuoS,ChengZ.Thewebofthings:asurvey(invitedpaper).JCommun.2011;6(6):424–438.
[20] KotisK,KatasonovA.Semanticinteroperabilityonthewebofthings:Thesemanticsmartgatewayframework.In:2012Sixthinternationalconfer ence on complex, intelligent and software intensive systems(CISIS);2012.p.630–635.
[21] Zafeiropoulos A, Spanos DE, Arkoulis S, et al. Data management insensornetworksusingsemanticwebtechnologies.Datamanagementinsemanticweb;2009.
[22] Khan I, Rifat J, Fatima ZE, et al. A data annotation architecture forsemantic applications in virtualized wireless sensor networks. arXivpreprintarXiv:1501.07139.2015.
[23] Compton M, Henson CA, Lefort L, et al. A survey of the semanticspecificationofsensors;2009.
[24] Zhang S, Wang H, Huang W, et al. Plant diseased leaf segmentationandrecognitionbyfusionofsuperpixel,K-meansandPHOG.Optik-IntJLightElectronOpt.2018;157:866–872.
[25] Patel A, Jain S. Formalisms of representing knowledge. ProcediaComputSci.2018;125:542–549.