General

ID[1]				
Use case name	Deep Learning Technology Combined with Topological Data Analysis Successfully Estimates Degree of Internal Damage to Bridge Infrastructure			
Application domain	Social infrastructure			
Deployment model	Cloud services			
Status	PoC			
Scope[2]	Estimate and detect the risk of the catastrophic collapses of old bridges			
Objective(s)	Enables estimation of failure, state of degradation with surface-mounted sensors			
Narrative	Short description (not more than 150 words)	Development of sensor data analysis technology that can aggregate vibration data from sensors attached to the surface of a bridge, and then estimate the degree of the bridge's internal damage		
	Complete description	Inspection tasks for bridges are usually performed visually to check the structure for damage. The issue with relying only on information gathered visually, however, is that inspectors can only identify abnormalities or anomalies appearing on the structure's surface, and are consequently unable to grasp information regarding the degree of internal damage. There have been many trials in which sensors were attached to the surface of the bridge deck, using vibration data to evaluate the level of damage. With the methods used until now, accurately understanding the degree of damage within the interior of the deck was an issue. Deep learning AI technology for time-series data can discover anomalies and express in numerical terms degrees of change that demonstrate drastic changes in the status of objects such as structures or machinery, and detect the occurrence of abnormalities or distinctive changes. The technology learns from the geometric characteristics extracted from complex, constantly changing time-series vibration data collected by sensors equipped on IoT devices, thus enabling users to estimate and validate the state of degradation or failure in a variety of social infrastructure or machinery. This technology has now been confirmed through the application of verification test data from RAIMS (Research Association for Infrastructure Monitoring System).		
Stakeholders[3]				
Stakeholders' assets, values[4]				
System's threats and vulnerabilities[5]				
Key performance indicators (KPIs)	ID	Name	Description	Reference to mentioned use case objectives
	1	Anomaly detection	The geometric characteristics extracted from the vibration data by this	Enabling to detect anomalous feature

			technology would appear as a single cluster when the bridge was intact, but the shape changes when the bridge had developed internal damage.	
	2	Change detection	The degree of abnormality and the degree of change that can be calculated by converting the geometric characteristics to numerical values correspond with the results measured by strain sensors embedded within the bridge deck.	Precise measure of anomaly

AI features	Task(s)	Recognition
	Method(s)[6]	Topological Data Analysis
	Hardware[7]	
	Topology[8]	
	Terms and concepts used[9]	Topological Data Analysis, Anomaly Detection, Time Series Classification, Convolutional Neural Network
Standardization opportunities/ requirements		
Challenges and issues	Challenges: Detecting the occurrence of internal stress using this technology allows for the estimation of damage in its earliest stages, and can contribute to early countermeasures. Issues: Conduct trials using vibration data from actual bridges, with the goal of real-world usage.	
Societal concerns	Description	
	SDGs[10]	(Select from pull-down menu)

Data (optional)

Data characteristics	
Description	
Source[11]	
Type[12]	
Volume (size)	
Velocity (e.g. real time)[13]	
Variety (multiple datasets)[14]	
Variability (rate of change)[15]	
Quality[16]	

Process scenario (optional)

		Scenario conditions			
No.	Scenario name	Scenario description	Triggering event	Pre-condition[17]	Post-condition[18]

Training (optional)

Scenario name	Training				
Step No.	Event[19]	Name of process/Activity[20]	Primary actor	Description of process/activity	Requirement

Specification of training data[21]	

Evaluation (optional)

Scenario name	Evaluation				
Step No.	Event[22]	Name of process/Activity[23]	Primary actor	Description of process/activity	Requirement

Input of evaluation[24]	
Output of evaluation[25]	

Execution (optional)

Scenario name	Execution				
Step No.	Event[26]	Name of process/Activity[27]	Primary actor	Description of process/activity	Requirement

Input of Execution[28]	
Output of Execution[29]	

Retraining (optional)

Scenario name	Retraining				
Step No.	Event[30]	Name of process/Activity[31]	Primary actor	Description of process/activity	Requirement

Specification of retraining data[32]	

References

No.	Type	Reference	Status	Impact on use case	Originator/organization	Link
				References		
1	Press Release				Fujitsu	http://www.fujitsu.com/global/about/resources/news/press-releases/2017/0828-01.html
2	Press Release				Fujitsu	http://www.fujitsu.com/global/about/resources/news/press-releases/2016/0216-01.html
3	Technical Paper	Time Series Classification via Topological Data Analysis			Transactions of the Japanese Society for Artificial Intelligence	https://www.jstage.jst.go.jp/article/tjsai/32/3/32_D-G72/_article
4	Technical Paper	Topological Data Analysis and its Application to Chronological Data Analysis			FUJITSU Journal (in Japanese)	http://www.fujitsu.com/jp/documents/about/resources/publications/magazine/backnumber/vol69-4/paper15.pdf

(Examples of other citation that cannot be described in the table format)

[1] Lominandze, DG. *Cyclotron waves in plasma*. Translated by AN. Dellis; edited by SM. Hamberger. 1st ed. Oxford : Pergamon Press, 1981. 206 p. International series in natural philosophy. Translation of: Ciklotronnye volny v plazme. ISBN 0-08-021680-3.

[2]Parker, TJ. and Haswell, WD. *A Text-book of zoology*. 5th ed., vol 1. revised by WD. Lang. London : Macmillan 1930. Section 12, Phyllum Mollusca, pp. 663-782.

[3]Wringley, EA. Parish registers and the historian. In Steel, DJ. *National index of parish registers*. London : Society of Genealogists, 1968, vol. 1, pp. 155-167.

[4]Communication equipment manufacturers. Manufacturing a Primary Industries Division, Statistics Canada. Preliminary Edition, 1970- . Ottawa : Statistics Canada, 1971- . Annual census of manufacturers. (in English), (in French). ISSN 0700-0758.

[5] Weaver, William. The Collectors: command performances. Photography by Robert Emmet Bright. Architectural Digest, December 1985, vol. 42, no. 12, pp. 126-133.

Footnote

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[1] Leave this cell blank.

[2] The scope defines the limits of the use case.

[3] Stakeholder involved in the scenario - examples are: type of organization; customers, 3rd parties; end users; humans; environment; negative stakeholders (attackers, criminals, etc).

[4] Assets and values that are valuable to the stakeholders and at the risk of being compromised by the AI system deployment – examples can include competitiveness; reputation or trust; fairness; safety; privacy; stability; etc.

[5] Threats and vulnerabilities can compromise the assets and values above. Examples are: different sources of bias; incorrect AI system use; new security threats; challenges to accountability; new privacy threats (hidden patterns).

[6] AI method(s)/framework(s) used.

[7] Hardware system used.

[8] Topology is the study of geometric forms differentiated by intersection and bifurcation. The term is used for the graphic aspects network architectures.

[9] Terms and concepts listed here can be used to extend the work of WG 1 (AWI 22989 and AWI 23053) as necessary.

[10] The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a collection of 17 global goals set by the United Nations General Assembly. SDGs are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.
See URL for more details: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html

[11] Origin of data, which could be from instruments, IoT, web, surveys, commercial activity, or from simulations.

[12] Structured/unstructured Images, voices, text, gene sequences, and numerical. Composite: time-series, graph-structured

[13] The rate of flow at which the data is created, stored, analysed, or visualized.

[14] Data from a number of domains and a number of data types. The wider range of data formats, logical models, timescales, and semantics complicates the integration of the variety of data.

[15] Changes in data rate, format/structure, semantics, and/or quality.

[16] Completeness and accuracy of the data with respect to semantic content as well as syntactical of the data (such as presence of missing fields or incorrect values)

[17] Describe which condition(s) should have been met before this scenario happens.

[18] Describe which condition(s) should prevail after this scenario happens. The post-condition may also define "success" or "failure" conditions.

[19] The event that triggers the step. This might be completion of the previous event.

[20] Action verbs should be used when naming activity.

21 Training data can be further specified.

22 The event that triggers the step. This might be completion of the previous event.

23 Action verbs should be used when naming activity.

24 Specify input of evaluation.

25 Specify output of evaluation.

26 The event that triggers the step. This might be completion of the previous event.

27 Action verbs should be used when naming activity.

28 Specify input of evaluation.

29 Specify output of evaluation.

30 The event that triggers the step. This might be completion of the previous event.

31 Action verbs should be used when naming activity.

32 Retraining data can be further specified.