Starting from the early years of the 21st century, the problem of monitoring the physical–chemical–mechanical conditions of structures and infrastructures for civil use began to be thought in a significantly different way than in the last century.

Since the appearance of the most common materials for civil use, in particular, reinforced concrete and steel, the structures made with them have been thought of almost as having an infinite life and subjected to checks only occasionally and, almost always, after traumatic events that could have strongly damaged them, such as earthquakes or landslides.

In the last twenty years, however, it has been realized that these materials have a long life but not indefinitely long. It has begun to be understood more and more that, as with many materials of the past, for example wood, carrying out correct and methodical maintenance is important and can greatly extend the useful life of a structure or infrastructure. This involves enormous economic gain for society, by also reducing environmental pollution, caused by demolished materials and/or materials needed for new buildings.

The constructions of the last century, however, are much more complex than the relatively simple masonry and wood structures of the years prior to the industrial revolution of the 19th century, although some exceptions were present at the beginning of the 19th century [1]. Skyscrapers, suspension and cable-stayed bridges, dams, particular industrial buildings, etc. they do not have easy maintenance and, often, the points where the degradation is concentrated are not immediately identifiable, also in consideration of the different and complex types of load to which they are subjected, often of a dynamic nature such as vehicular traffic, earthquakes, wind, etc., as well as environmental effects (particularly corrosive atmospheres, humid environments, etc.).

For large structures, especially publicly owned ones, an attempt was made to define a periodic control and monitoring plan, with maintenance interventions also scheduled. Despite this, both due to phenomena of scarce funding and bad use of funds, this programming has often not been correctly implemented and there have also been collapses that have produced numerous human victims (for those who know and frequent Italy, it is sadly famous the collapse of the Morandi bridge in Genoa in August 2018).

For smaller structures or for those of private property, then, the maintenance of this programming is even more complicated and difficult to perform, also because the owners do not always have the skills to perceive the danger that a damaged structure can entail.

All the arguments previously described have led to the modern concept of structural health and the need for its monitoring, similarly to what happens for human health. Indeed, considering the rapid and incisive diffusion of the concept, the acronym SHM has been introduced to briefly indicate Structural Health Monitoring, which is an interdisciplinary subject that incorporates synergistic knowledge and experience technologies in civil, mechanical, control and computer engineering.

In the first instance SHM foresees the detection of any structural damage, alerting the technicians in charge of maintenance to the need for inspection and repair and/or reinforcement. Very often, SHM systems stop at this level, but more and more frequently
they begin to predict the localization and quantification of damage. The thing is not easy and it is almost always necessary to introduce artificial intelligence techniques, such as neural networks or genetic algorithms, whose “training” is obtained by simulating the behavior of the structure in the presence of various damages using computational mechanics. Finally, also for the purpose of planning maintenance and evaluating the compatibility of its economic cost, there is the prevision of the remaining life. In summary, SHM includes: (1) detection, (2) localization, (3) quantification and (4) prevision of remaining life.

Being clear that the SHM is multidisciplinary, the guest editors proposed to the scientific community to contribute to this Special Issue of Applied Sciences international journal, discussing the innovations relating to the methods and materials that allow to evaluate the health status of a structure or infrastructure, limited to those of civil use.

Several topics are related to the Special Issue, such as intrinsically diagnostic materials [2], or composites [3], modeling of structures using finite element methods [4], and recently SHM connected with IoT [5]. Problems of surveying structures, methods useful for remote monitoring of infrastructures, in particular, bridges [6] or works of historical-monumental importance were also addressed [7]. Recently, the guest editors have also started to evaluate the economic effects of the SHM, in particular on the estimated value of residential buildings [8].

Since SHM is interdisciplinary, several research fields are involved. Among them we can emphasize the following ones:

(a) The Computational Mechanics. In fact, it is important to simulate the intact and damaged structure in order to identify the presence of the damage and evaluate its position and entity. Without it, the cases that an Artificial Intelligence method uses to train oneself to interpret the data coming from the sensors to arrive at the correct definition of the damage, could hardly be populated. Fundamental concepts in Elasticity, Mechanics and Wave Propagation, Signal Processing, Application of the Finite Element Method in SHM, Spectral Finite Element Method, are some of the important aspects for SHM of competence of this discipline [9].

(b) The Theoretical Analysis of Structures, especially the dynamic one. It is necessary to develop static and dynamic analysis methods, adapting well-known theories to be able to simulate the behavior of a structure and to interpret the data coming from the sensors, which measure static quantities (translations and rotations, temperatures, inclinations, etc.) or dynamic ones (accelerations, vibrations, etc.) [10,11].

(c) The New Materials. There are self-diagnostic materials that can become sensors themselves and make it possible to identify the damage. Furthermore, materials capable of self-repairing and materials that allow a structure to change shape or to react to stresses are appearing (i.e., smart, adaptative and intelligent materials). In the near future, these materials will be of great importance in structural monitoring [12].

(d) The Electronics, Sensors, often in connection with the Internet of Things (IoT), in the measurement of mechanical and structural characteristics. It is important to develop new accelerometers, less intrusive and expensive, possibly connected wirelessly. However, also classic sensors such as strain gauges, inclinometers, LVDTs, etc., must be rethought as a function of modern monitoring, hopefully to be carried out remotely and for a large number of structures [13].

(e) The Artificial Intelligence (Neural Networks, Genetic Algorithms, Machine Learning, etc.) that now pervades most of the technological applications and that allows to make the structure as well as smart even cognitive, that is, able to predict future damage, thus significantly helping scheduled maintenance [14].

(f) Finally, Geomatics and surveying techniques in the continuous and discontinuous monitoring of structures. Today, monitoring can make use of modern techniques for measuring displacements and other geometric quantities, such as detection and measurement by using radio waves (RADAR), or light (LiDAR), photogrammetry, multispectral satellite images, radar synthetic aperture (SAR) [15], infrared thermography, and image analysis methods, including digital image correlation (DIC),
ground penetration radar (GPR) and remote acoustics [16]. Another important issue is the classification of buildings and neighborhoods for carrying out emergency plans [17,18].

About the Present Special Issue
Several interesting contributions are proposed in this special issue. The influence of temperature on the displacements of bridge and their structural elements is analyzed by Zhao et al. [19] and by Yang et al. [20]. The effect of humidity is taken into account for timber bridges by Fortino et al. [21].

The Structural Health Monitoring Systems is performed with the Artificial Intelligence by Chiaia and De Biagi [22], while Ozer and Feng propose the Participatory Sensing and Mobile Cyber-Physical [23].

Pepe et al. present a pipeline to obtain 3D Model for HBIM from 3D Point Clouds [24].

An application concerning the GPR survey for infrastructure maintenance is developed by Kovačević et al. [25].

Applications in the field of geomatics are also proposed. The assessment of the structural health status can be performed with different geomatic techniques by means of static measurements [26–28] and dynamic ones [29–31].

The latest contribution is a review of the Subspace System Identification (SSI) method for health monitoring [32].

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