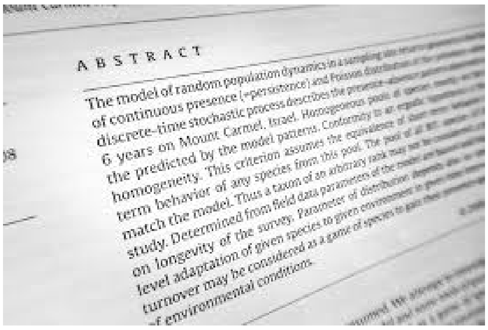
Building a work plan



ABSTRACT

The model of random population dynamics in a sampling
of continuous presence (=persistence) and Poisson distribution
discrete-time stochastic process describes the presence
6 years on Mount Carmel, Israel. Homogeneous pools of species
the predicted by the model patterns. Conformity to an
homogeneity. This criterion assumes the equivalence of
term behavior of any species from this pool. The pool of
match the model. Thus a taxon of an arbitrary rank may
study. Determined from field data parameters of the model
on longevity of the survey. Parameter of distribution
level adaptation of given species to given environment
turnover may be considered as a game of species
of environmental conditions.

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What is a research plan ?

- You have a crictical state-of-the-art, what should you do next ?

- Identify what can be used in your project
- Identify what is lacking
- Define clearly your objectives/sub-objectives
- Develop a methodology to reach your objectives
  - Divide your work into tasks/work packages
  - Link the tasks together (Pert chart)
  - Make a provisional timeline (Gantt Chart)

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Example of a research plan

(4 pages project description)

1. **Goals of the research**

This project proposal is prepared with an objective to address the problem of **robust optimization of tuned-mass-dampers (TMD) in case of real-life problems consisting of large-scale structures and several variability and uncertainties**.

The novelty of this proposal is that the proposed problem shall be attempted in a computationally efficient manner with the use of advanced stochastic optimization techniques and model reduction approach.

The new developments in this project will allow to move from ideal academic problems to complex real life cases, opening numerous possibilities of collaborations with design offices all around the world who could benefit from such techniques to optimize different types of TMDs in different loading conditions.

Thus, improving safety and comfort in civil engineering infrastructures is the major expected outcome of the project for the society at large.

Setting the context

1. **State of the art**

(Context)

Tuned mass dampers are passive devices consisting of mass-spring-damper system(s) attached to the main vibrating system (host-structure) to reduce the undesirable vibrations of the host-structure (Figs. 1-2).

Various researchers [1-4] have optimized the TMD system for different combinations of idealized host-structural systems such as single-degree-of-freedom (SODF) and limited multi-degree-of-freedom (MDOF) systems subjected to white noise.

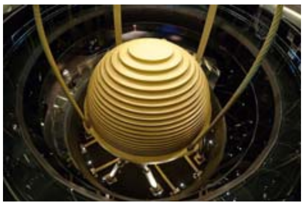

Figure 1. Tuned mass damper at top of Taipei 101 building (taken from https://www.atlasobscura.com/places/tuned-mass-damper-of-taipei-101)

Figure 2. The TMD used in the passenger foot-bridge (taken from http://www.roadjz.com/en/show.asp?id=18)

Identifying the current limitations

(Limitations)

However, the authors of this research-proposal have not come across any literature so far that has optimized a TMD system in case of a **large-structural system subjected to nonstationary earthquake excitations**.

One of the major reason behind not attempting so previously seems to be the **excessive computation cost of optimization**.

In routine engineering practice, the optimal TMD parameters are determined for simple cases and then their effectiveness is evaluated in case of real-life complicated problems.

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Identifying the current limitations

(Limitations)

However, it is the belief of the authors of this proposal that such a TMD system would be sub-optimal since those are not optimized under the actual conditions.

It is well understood that real-life host-structures are never SDOF systems, in fact, those are practically associated with a huge number of modes of vibration and the actual conditions may sometimes require that the TMD be tuned to the higher modes of vibrations.

Another important aspect in the real-life applications is the presence of the following uncertainties [5-9]:

1) Uncertainties related to the loading itself (nonstationary stochastic excitation)
2) Uncertainties related to the host structure (mass, stiffness, damping, natural period)
3) Uncertainties related to the installed TMD parameters

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Identifying the current limitations

(Limitations)

Thus, the optimization of TMD parameters for large-scale structures would become **even more computationally costly** and complicated if these uncertainties are also accounted for.

Recently, one of the authors of this proposal has used the model reduction technique to optimize a complex finite element model of a 30-storey building [10] and concluded that the efficient model reduction strategy can provide true optimal parameters for large-scale systems at a very small computational cost.

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Identifying the current limitations

(Limitations)

Further, previous studies have selected a few ground motions in a very subjective manner to check the effectiveness of the TMD systems and no consensus has been developed till date for selection of ground motions.

To address this issue, in this project, **design response spectra as specified in various seismic design codes** shall be used instead of arbitrarily selected earthquake time-histories.

It is also noted that previous studies (e.g., [11]) have evaluated the effectiveness of the TMD parameters by comparing the response spectra of host-structure with and without TMD. However, **there is no study that uses the response spectra as its objective function**.

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Defining the methodology/main ideas of the project

(Motivation/Methodology)

Therefore, **it would be worthwhile to optimize the TMD parameters for a given design response spectrum**.

To achieve this objective, unlike previous studies, stochastic ground motions can be generated that are compatible to a given response spectra and then those response spectrum compatible ground motions can be used to optimize the TMD parameters.

Since, a response spectrum can be associated with infinite number of random ground motions, this approach would be helpful in accounting for the temporal uncertainties of the stochastic excitation as well.

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Defining the methodology/main ideas of the project

(Methodology)

The uncertainties in structural properties (mass, stiffness, damping, and natural period) are caused due to the (i) errors in modelling of the boundary conditions at the structural joints, (ii) effects of non-structural components, (iii) degradation due to aging, (iv) variability in temperature and humidity, and (v) fluctuations in structural mass as well as uncertainties in member capacities, and yield strength.

Another critical uncertainty may arise due to the detuning of the TMD parameters caused by time-dependent deterioration, strong earthquakes or winds, and the fabrication process itself.

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Defining the methodology/main ideas of the project

(Methodology)

These type of uncertainties are commonly characterized by using the multi-dimensional joint probability density function of all involved uncertain parameters and then Monte-Carlo simulation (MCS) technique is used to generate random input parameters for the optimization process.

The optimization in case of real-life applications would become unimaginably costly if all the above mentioned uncertainties are also involved. Therefore, it is proposed that these type of uncertainties can be accounted for by using an efficient MCS technique combined with the efficient model reduction based optimization strategy.

Defining the methodology/main ideas of the project

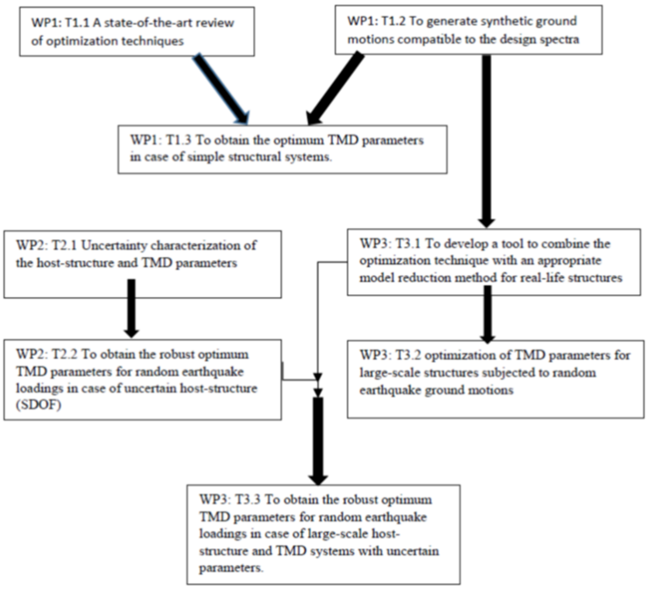
(Methodology)

Another important challenge would be to select the most **efficient optimization method**. For example: [12] compared the conventional deterministic optimization to the robust single-objective and multi-objective optimization methods that account for the uncertainty in the applied excitation only.

The major limitation of such a robust optimization is that it analyzes only a SDOF system. For a SDOF system, it is demonstrated that the multi-objective robust design methodology significantly improves the performance.

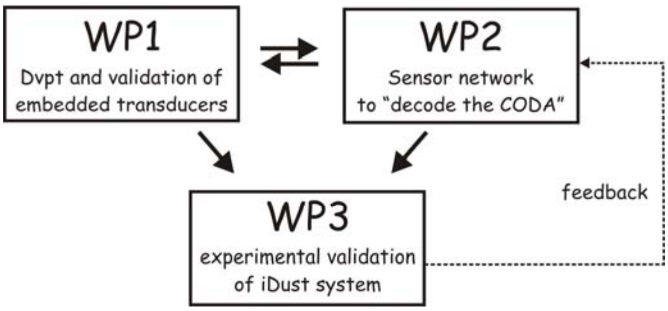
Recently, some of the studies [13-14] have adopted **metaheuristic algorithms** such as harmony search method and the bat algorithm for optimization of TMD parameters in case of ten-story buildings.

The Pert chart : structuring the work



The Pert chart : structuring the work

Other example



Detailed description of the work

WP1: Optimization of TMDs under random earthquake excitation
The main objective of this work package would be to optimize the TMD attached to the idealized structures (single and double degree-of-freedom systems) for random earthquake loadings characterized by a given response-spectra. This objective is proposed to be achieved through the following tasks and resulting deliverables:

Task-1 (T1.1): A state-of-the-art review of various deterministic, stochastic, and metaheuristic optimization techniques (For example [12-14]) for TMD parameter determination in earthquake loading scenario accounting for various sources of uncertainties.

Deliverable-1 (D1.1): A recommendation on the appropriate optimization technique to be used in the project.

Detailed description of the work

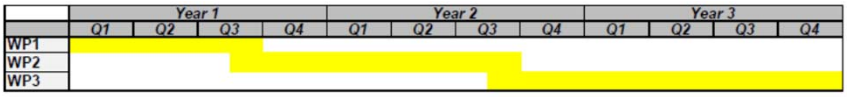
Task-2 (T1.2): To generate synthetic ground motions (e.g., [15]) covering a wide range of temporal features, compatible to the design spectra given in various building codes.

Deliverable-2 (D1.2): A catalogue of earthquake ground motions for which the TMD parameters shall be optimized.

Task-3 (T1.3): To obtain the optimum TMD parameters using the D1.1 and D1.2 in case of simple structural systems.

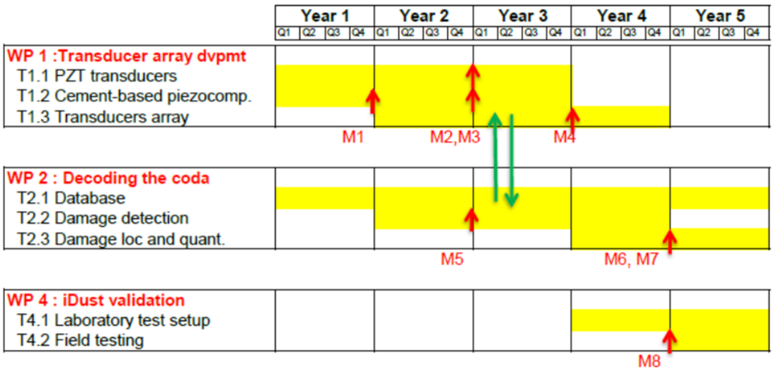
Deliverable-3 (D1.3): Preparation of a manuscript based on the work in this package.

Making a time-line: the Gantt chart



This is a very simple one (due to space limitations)

Other example



Summary for report

- **A short abstract** (½ page)
- **An introduction** giving the background, context and motivation and general objective of the work (1-2 pages)
- **A critical and structured state-of-the-art** containing the most important references, a description of the relevant information from these publications and their link with the topic of the research, as well as their adequacy or limitations with respect to the problem treated. The state-of-the art should clearly identify the gaps in the existing methods/applications which motivate the research and define the goals. (2-3 pages)

Summary for report

- **A clear and structured work plan**. The work plan should be clearly linked to the gaps identified in the state-of-the-art and be aimed at filling these gaps, by proposing specific methods. In doing so, the work should be structured in tasks, which are themselves gathered in work packages. A Pert chart showing the links between work packages and tasks (which output result is used as an input to which task?) should be included (2-3 pages)

- **A tentative schedule**. At this stage it is important to imagine how the tasks defined in the work plan should be arranged in time in order to finalize the research work by the end of the academic year. As always in research, this is only tentative and will be used as an adaptable roadmap during the thesis. (1 page)