Ground motion selection for HC-IDA using genetic algorithms

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Background and Motivation

- Hazard-consistent incremental dynamic analysis (HC-IDA) is a recently developed procedure to compute hazard-consistent collapse risk estimate by post-processing the results of IDA.
- It is an alternative to the commonly employed hazard-consistent multiple stripe analysis (MSA) procedure, without the need for site and structure specific ground motions.

Image source:HiClipart; www.pngitem.com

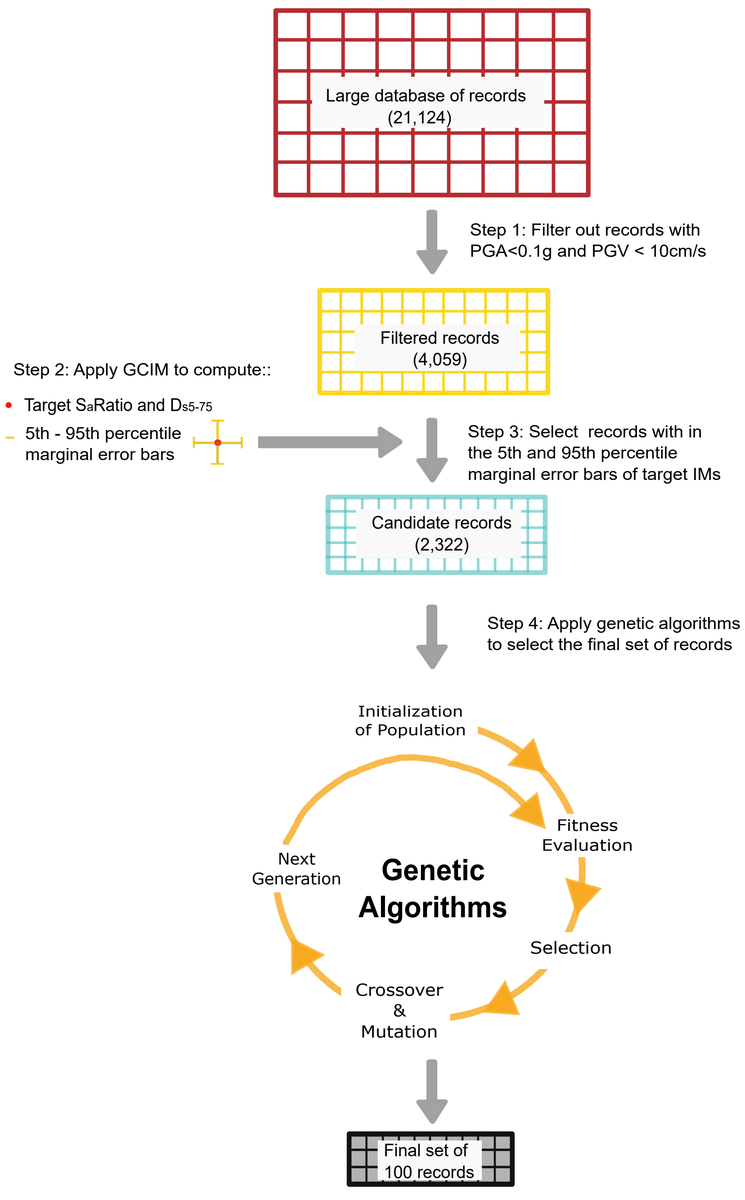
- A careful selection of generic ground motions set is required for HC-IDA to reduce bias and variance in predicting structural response.

Objectives

- To select a set of ground motions over a wide range of response spectral shapes (S_aRatio) and duration(Ds_{5-75}) anticipated around various seismic sites, consistent with the following criteria:
  - uniform spread out of S_aRatio and Ds_{5-75} values of the selected ground motions over the area defined by the 5th and 95th percentile marginal error bars of the targets
  - orthogonality between S_aRatio and Ds_{5-75} values of the selected ground motions

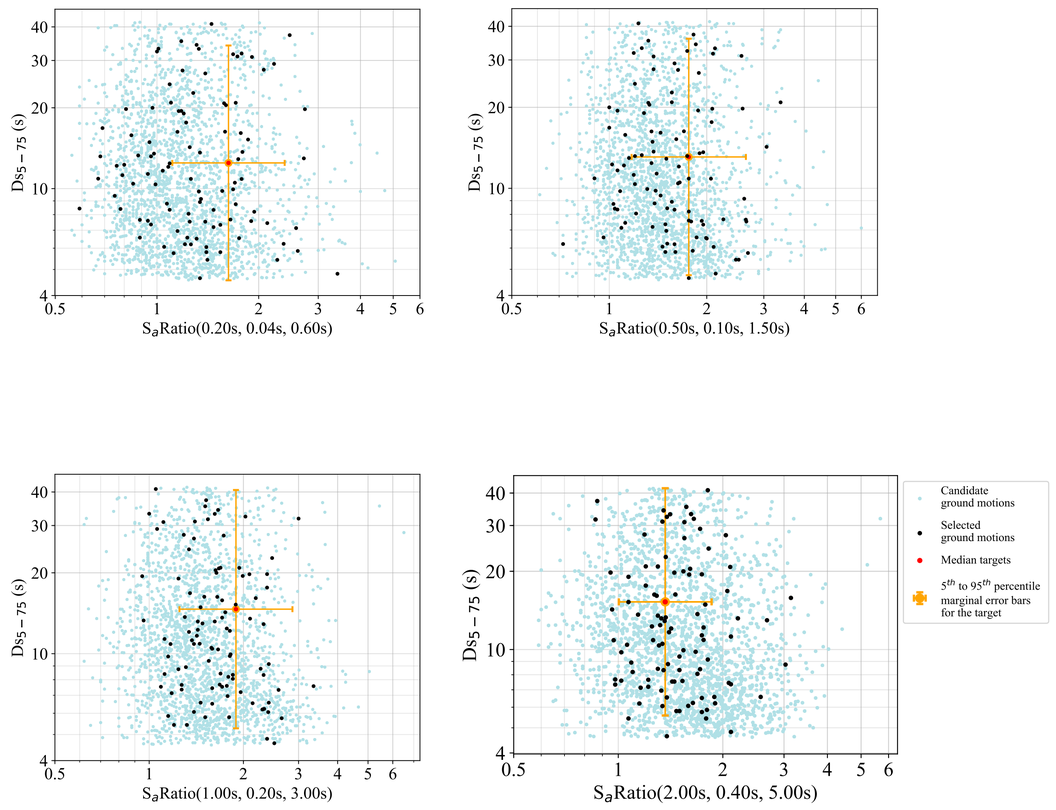
Ground motion selection procedure

- An overview of complete process of selecting a generic set of ground motions
  - Generalized conditional intensity measure (GCIM) approach is employed to compute target distributions of S_aRatio and Ds_{5-75}
  - Genetic algorithms (GAs) is employed to optimize the selection process. GAs are a series of algorithms that mimics an evolutionary process of natural selection.



Selected ground motions

- All the 100 ground motions selected for HC-IDA are plotted as black dots over the candidate ground motions, along with the median targets conditioned on $S_a(0.2s)$, $S_a(0.5s)$, $S_a(1.0s)$, and $S_a2.0s)$.
- The selected ground motions can be applied for structures with fundamental time period range of 0.2s to 2.0s.



Evaluation of the selected ground motions

- IDA is conducted on a 4-story steel moment resisting frame building, designed according to the New Zealand Standards to represent a typical office building in Wellington CBD area.
- The nonlinear hinges incorporate modified Ibarra-Medina-Krawinkler (IMK) bilinear hysteretic model.

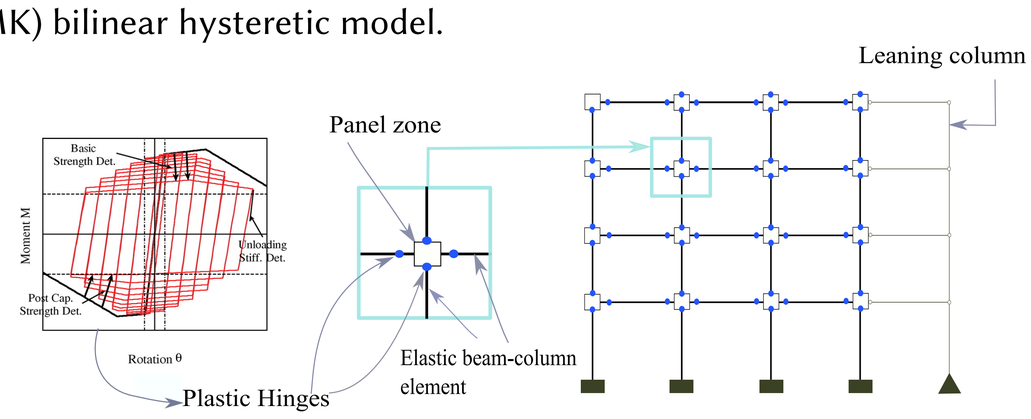
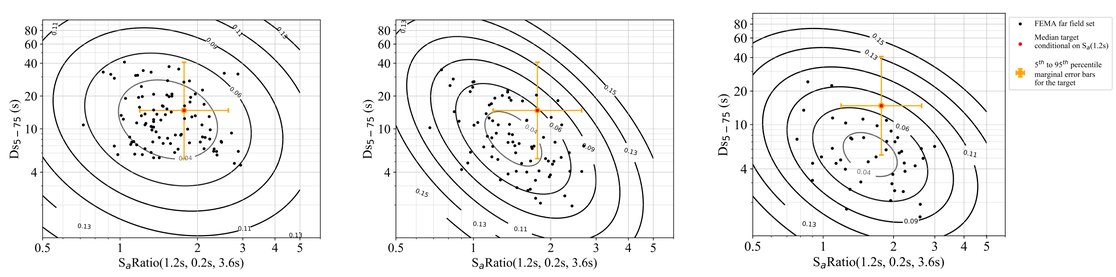


Image source:(Lignos Krawinkler, 2011)

- Standard error in predicting the mean collapse intensity in the region bounded by the 5th and 95th percentile marginal error bars of the median targets of S_aRatio and Ds_{5-75}, is computed using HC-IDA:

(i) Selected set ; (ii) PEER broad-band set; (iii)FEMA P695 far-field set



Conclusions

- A procedure based on genetic algorithms is proposed to select a generic set of ground motions covering the range of ground motion response spectral shape and duration anticipated in New Zealand.
- The lower prediction standard error of the selected set of ground motions, compared to the PEER broad-band set and the FEMA P695 far-field set, reflects merit of selecting ground motions consistent with requirements of HC-IDA.