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Approved for Public Release

## VANNEVAR BUSH FACULTY FELLOWSHIP

### Project Title: **Data Geometry, Semantics, and Information**

#### Project Abstract:

*The goal of this proposal is to investigate how information and knowledge can be inferred from and transported across correlated data sets at large scales – especially between data of a geometric or visual character (images, videos, 3D scans, GPS trajectories). We aim to combine current deep learning “vertical” networks that move information across abstraction layers for one data set with “horizontal networks” that transfer information between corresponding layers in different but related data sets. The links of these horizontal networks are based on a novel functional formulation for traditional maps and correspondences, using a linear algebraic setting.*

*We investigate the construction of deep architectures able to process irregular geometric data of variable size, such as point clouds or various types of simplicial complexes, including traditional 2D meshes. Inspired by algebraic topology and homological algebra, we look at latent spaces or data abstractions that are not just points in a Euclidean space but more structured algebraic objects that can reflect semantic structure in the original data in a more transparent way – making reasoning at the abstraction level more efficient. Our horizontal networks are synergistic with deep learning networks and can help regularize and denoise their results, reducing the amount of supervision necessary. Beyond information transport, such networks are able to extract shared low-dimensional structure from the data and obtain reduced parametrizations of the variability present, using low rank matrix approximation techniques.*

*On the application side, we aim to enable the creation of curated knowledge-bases in the cloud encoding both objective and subjective knowledge about objects in the world and then deliver such information with precision to new settings, as needed by human or robotic agents. The proposed relational approach facilitates a variety of novel applications, including searching for data based on its relationships to other data, design informed by related past designs, the augmentation of sensor information with inferred knowledge via the network, and the ability to link scientific and educational communities through their data.*