

Statistics on Special Manifolds

The special manifolds of interest in this book are the Stiefel manifold and the Grassmann manifold. Formally, the Stiefel manifold $V_{k,m}$ is the space of k frames in the m -dimensional real Euclidean space R_m , represented by the set of $m \times k$ matrices X such that $X'X = I$, where I_k is the $k \times k$ identity matrix, k and the Grassmann manifold $G_{k,m-k}$ is the space of k -planes (k -dimensional hyperplanes) in R_m . We see that the manifold $P_{k,m-k}$ of $m \times m$ orthogonal projection matrices idempotent of rank k corresponds uniquely to $G_{k,m-k}$. This book is concerned with statistical analysis on the manifolds $V_{k,m}$ and $P_{k,m-k}$ as statistical sample spaces consisting of matrices. The discussion is carried out on the real spaces so that scalars, vectors, and matrices treated in this book are all real, unless explicitly stated otherwise. For the special case $k = 1$, the observations from $V_{1,m}$ and $G_{1,m-1}$ are regarded as directed vectors on a unit sphere and as undirected axes or lines, respectively. There exists a large literature of applications of directional statistics and its statistical analysis, mostly occurring for $m = 2$ or 3 in practice, in the Earth (or Geological) Sciences, Astrophysics, Medicine, Biology, Meteorology, Animal Behavior, and many other fields. Examples of observations on the general Grassmann manifold $G_{k,m-k}$ arise in the signal processing of radar with m elements observing k targets.

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