



Fig. 7. Tensorial solution of an overcomplete sensorimotor transformation and its quantitative (matrix and network) implementation. Combined results of Figs. 4–6, provide a complete set of three intrinsic transformations that convert a three-dimensional covariant vestibular vector s_r into a six-dimensional overcomplete contravariant extraocular vector m^e . The intrinsic transformations can be connected (if desired) to any extrinsic frame, e.g., by the intrinsic vestibular- and extraocular matrices of V and E (Fig. 2). The shown numerical example of a particular vestibular input vector s_r is selected since it corresponds to the one in Fig. 3, the case of maximal horizontal stimulation. The scheme can be used for calculation of any eye-muscle activation, emerging from a given vestibular input. In the example shown, note that the activation of ‘agonist-antagonist’ muscles may yield a grossly asymmetrical contraction of, e.g., the SR and IR muscles, which are activated in a 26.7:1.0 ratio. In addition, both muscles are inactivated rather than acting in a push-pull manner. The tensorial scheme requires two interim vectorial expressions of s^p and m_i , and thus calls for three separate transformation matrices of vestibular metric tensor g^{pr} , sensorimotor embedding c_{ip} , and oculomotor metric g^{ie} . It is suggested that the interim expression s^p is implemented in the secondary vestibular neurons which receive projections from all canals, and m_i is in the premotor neurons of the internuclear brain stem mechanism.

variant-to-covariant relation is established by the covariant metric tensor, transforming an Eigenvector into an Eigenvector magnified by an Eigenvalue, the contravariant metric-type transformation is expected to change the same covariant Eigenvector into a contravariant one, re-

duced by the same Eigenvalue. This conceptual argument leads to the Moore-Penrose generalized inverse of the covariant metric, which yields the required matrix. Indeed, the reader can verify that both g^{ie} (Fig 6F) and g_{ie} (Fig. 6C) share the same Eigenvectors, tabulated in Fig. 6E.