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Physically-based invertible deformation simulation of solid objects

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With an increased computing capacity of computer, physically based simulation of deformable objects has gradually evolved into an important tool in many applications of computer graphics, including haptic, computer games, and virtual surgery. Among physically based simulation, large deformation simulation of solid objects has attracted many attentions. During large deformation simulation, especially interactive simulation, element inversion may arise. In this case, standard finite element methods and mass-spring systems are not suitable because they are not able to generate elastic internal forces to recover from the inversion. This presentation will describe a method for invertible deformation of solid objects. We derive internal forces and stiffness matrix of invertible isotropic hyper-elastic material from the energy density function. This method can be applied to arbitrary isotropic hyper-elastic material when the energy density function of deformable model is given in terms of strain invariants. In order to achieve realistic deformation, volume preservation capacity is always pursued as an important property in physically based deformation simulation. We will discuss about the volume preservation capacity of three popular invertible materials: Saint-Venant Kirchhoff material, Neo-Hookean material and Mooney-Rivlin material from the perspective of the volume term in the energy density function. We will demonstrate how the volume preservation capacity of these three materials changes with their material parameters, such as Lame coefficients and Poisson's ratio. Since the process of solving the new positions of mesh object can be transferred to independently solving the displacement of each vertex from the motion equilibrium equation at each time step, it enables us to utilize CPU multithread method to speed up the calculations. We will also present a CPU multithread implementation of internal forces and stiffness matrix.

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Visual odometry and mapping for unknown motion dynamics in natural environments using passive sensors

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The real-time recovery of vehicle pose and the estimation of the sparse geometrical structure of the surrounding environment in natural landscapes using monocular vision and passive sensors (excluding GPS) has received little attention in literature thus far, mainly because it is a very ill-posed problem. The motivation for the current research stems from GPS-denied scenarios involving autonomous vehicle navigation in natural environments (e.g., space exploration rovers, sea-surface vehicles, etc.). The natural cornerstone of vision based localization algorithms is the detection and tracking of a sparse set of point-features throughout a sequence of images. In natural scenes, we show that features can be more reliably tracked using optic flow estimation in comparison to descriptor/patch matching approaches. We introduce an algorithm for camera pose estimation and 3D mapping in real time which circumvents the typical execution scaling in the number of features of SLAM algorithms by marginalizing the entire map out of the state vector. The rationale behind this approach is to parametrize the 3D locations of the features in terms of the relative pose between the two initial frames in the sequence. This apprtoach fundamentally relies on the assumption that tracking is accurate between the first two frames and therefore, the uncertainty of the map is primarily associated with relative pose. We show that in natural scenes, provided optic flow based tracking and efficient treatment of outliers, real-time odometry is accurate and mapping is fairly reliable in practice.

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