The theory of robotic grasp and In-Hand Manipulation spans different decisions a robot needs to make while manipulating an object. The goal of an In-Hand Manipulation is either to reposition the object or to change the placement of robotic fingertips on the object's surface. The contact kinematics that a robotic hand adopts could be based on rolling, sticking, or sliding architectures. The thesis presents formulations to map the high-level tasks to servo-level planning or control architectures so that the desired manipulation target and contact architecture is achieved. The algorithms are based on a unified structure wherein an appropriate manifold/ surface is devised, and the task is referred to as a goal pose. Subsequently, an appropriate path metric is defined on the manifold to achieve the desired manipulation behaviour.

Geodesic-based contact curves on the object surfaces are examined in the context of rolling based In-Hand Manipulation. Then, a set of modified governing equations are described, which are used to kinematically reject sliding based disturbances during In-Hand Manipulation. A corollary proves that geodesic-based contact curves are generated on one of the contacting body whenever rolling constraints are imposed, and geodesic based contact curves are synthesized on other contacting body. Apart from planning using geodesic curves on the physical object's surface, geodesic curves on the manifold containing manipulability matrices, which are positive symmetric definite, are used. A directed search algorithm is presented to determine the optimal location of the fingertips on the object's surface while targetting the desired angular motion. Another issue during In-Hand manipulation is the limited workspace of the robotic hands. Prac- tical robotic hands are limited in imparting large manipulation to the object. To overcome the limited work-space of In-Hand Manipulation architectures, gaiting based planning methodol- ogy is also presented. A manipulability based metric is defined to search for grasp poses for a manipulation task. A geodesic based path is devised to relocate the fingertips on the object's surface such that the intermediate transitory grasp poses remain close to force closed condi- tions. In another method for manipulations, a partition of the fingers of a hand into passive support units and actively controlled units is proposed. A decision methodology is proposed for choosing the fingertips to support the object while the other fingertips are actively manip- ulating the object. A projected gradient descent method is proposed to achieve the choice of fixed and moving fingertip contacts. The architecture is useful as two of the fingertips passively support the object while the other two fingertips actively manipulate the object. Apart from the algorithms relating to hard finger based robotic manipulation, some insight is provided for the utility of conformal grasps using a soft fingertip. In the specific case of grasping using soft finger, a "sliding-mode" control algorithm is

presented to compute the desired internal forces in the absence of complete information of the object surface. A proof of the boundedness of relative angular velocity of surfaces in contact with local second-order conformity and bounded slip conditions is presented.