**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI**
**SHORT ABSTRACT OF THESIS**


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Thesis Title: Computational modelling and analysis of coupled adhesion and friction in gecko spatula peeling


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## SHORT ABSTRACT


A systematic investigation of the coupled adhesion and friction in gecko spatula peeling from a flat, rigid substrate is carried out using a computational model. A framework capable of resolving atomic-scale interactions as well as the finite deformations of the interacting bodies is developed within the setting of nonlinear finite element (FE) analysis. A surface enrichment strategy is employed to accurately and efficiently capture the nonlinear van der Waals forces at the interface. It is shown that partial sliding of the spatula in the peeling zone stretches the spatula, increasing its strain energy. This increase in strain energy is much higher for low peeling angles, which leads to an increase in the pull-off forces. The spatula is shown to detach at a constant critical detachment angle, irrespective of the peeling and the shaft angles. It is also shown that the “frictional adhesion” behaviour, until now only observed from seta to toe levels, is also present at the spatula level. A detailed parametric study is carried out to investigate the influence of various parameters - such as the peeling angle, spatula shaft angle, pad thickness, material stiffness, friction coefficient, and shaft length - on the pull-off forces and the critical detachment angle. It is shown that increasing the pad thickness beyond a certain level does not lead to a significant increase in the pull-off forces. Further, for pad thickness greater than 10 nm, for large peeling and shaft angles, the sliding of the spatula on the substrate is not observed. This behaviour is found to influence the invariance of the critical detachment angle. Even though decreasing the material stiffness increases the pull-off forces due to the increase in compliance, it also increases the stresses inside the narrow peeling zone, which could potentially lead to material failure. It has also been observed that the critical detachment angle remains invariant for a wide range of spatula shaft lengths. Comparison of the FE simulations using two-dimensional (2D) and three-dimensional (3D) spatula models strongly indicates that the 2D model can capture almost all the essential features of the peeling behaviour. Bayesian regularization based backpropagation learning method is used to train an artificial neural network (ANN) models to predict certain aspects of the spatula peeling behaviour. It is shown that by augmenting the FE models with ANNs, a significant reduction in computational cost can be achieved without compromising on the accuracy.