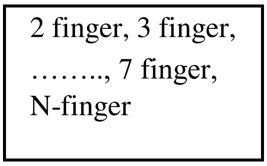
GRIPPING FORCE ANALYSIS OF JAMIA HAND

By Danish Daneyal

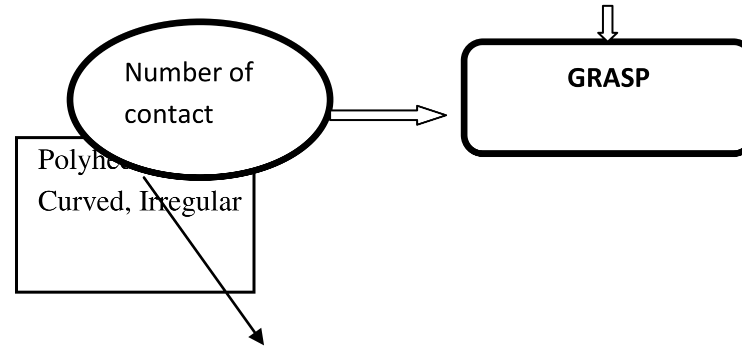
Abstract: Robotic hand increases the adaptability of grasping and manipulating objects with its system. But this added adaptability of grasping convolute the :process of grasping the object. The analysis of the grasp is very much complicated and large number of configuration for grasping is to be investigated. Handling of objects with irregular shapes and that of flexible/soft objects by ordinary robot grippers is difficult. It is required that various objects with different shapes or sizes could be grasped and manipulated by one robot hand mechanism for the sake of factory automation and labour saving. Dexterous grippers will be the appropriate solution to such problems. Corresponding to such needs, the present work is towards the contact force calculation and analysis of envelope grasping of tendon driven robotic gripper model JAMIA HAND with three finger and one thumb having eleven degree of freedom , three DOF for each finger and two for thumb total eleven DOF having an improved grasp capability. Further the force applied by the Fingers and there point of application is also being calculated so as to have a stable force closure grasp. The method introduced in present study reduces the complexity and computational burden of grasp synthesis by examining grasps at the finger level. A detailed study on the force closure grasping capability and quality has been carried out. The workspace of the five fingered hand has been used as the maximum spatial envelope. The problem has been considered with positive grips constructed as non-negative linear combinations of primitive and pure wrenches. The attention has been restricted to systems of wrenches generated by the hand fingers assuming Coulomb friction. In order to validate the algorithm vis-a-vis the designed five fingered dexterous hand, example problems have been solved with multiple sets of contact points on various shaped objects. Since the designed hand is capable of enveloping and grasping an object mechanically, it can be used conveniently and widely in manufacturing automation and for medical rehabilitation purpose.

Introduction:

From last few decades Robot kinematic analysis is a challenging area for the researcher to work on, because of robotic use in vast areas where complexity, dexterity are there. Now a day the demand of robot is increasing in the Industrial as well as in Domestic areas. Research is being done according to the demand and requirement. For Industrial purpose the robots are being used for welding, assembling etc. while for Domestic purposes it is used for pool cleaning, domestic vacuum cleaning etc. the robots apart from these it is being used in military, in robot assisted surgery etc. Thus we can say that in future its demand is going to be very high. But with demand, there will be demand of intelligent robots i.e., the robots that can perform the entire task like human being. For this one of the important properties that are required is the grasping capability of the Robots. Hence grasping has become an important field of robotic research. Simple grippers and task oriented end effectors are being generally used in various applications. But for this kind of end effector the area of application is very less. Hence dexterous multi-fingered hands represent an interesting research area. Two of the major issues in the area are; design of more dexterous hand, and its grasp capability including quality of grasp. Robotic assembly and welding operations demand more dexterous and compliant devices to overcome the complicacies demanded by the desired motion and object manipulation. These research topics are technological and scientific challenges. Before obtaining a fully operational dexterous hand there are many problems to be identified and solved. Up to the present time, a number of multi-finger hands have been developed. However, there has been little work pertaining to the planning of grasp for articulated hands which behave as several co-operating robots. Stable grasp must also be maintained in the manipulation process. Difficulties of realizing such a fine manipulation arises out of difficulty to obtain sufficient information about the state of the hand and the object in real time. Multi-fingered robot hand (MFRH) provides a promising base for supplanting human hand in execution of tedious and complicated tasks. Grasp planning is one of the key issues for this kind of dexterous robot hands.

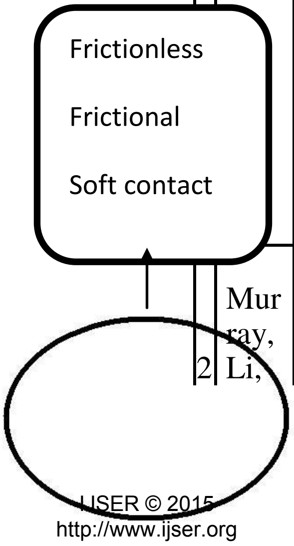


Type of contact



Data's required for planning a grasp

1	Toru Omata	1993	Finger Position Computation for 3 dimensional Equilibrium Grasps	Shown that in a planar grasp, the moment equilibrium equation can be made linear by replacing each real finger by a pair of virtual fingers fixed at the vertices of the region. They also discussed about the finger position computatin for 3-dimensional
2	Murray, Li,	1994	A Mathematical	Summarized that for various contact



	and Sastry		Introduction to Robotic Manipulation.	models to grasp an object three/four contacts are sufficient for any 2D/3D object with friction.
3	Jean ponce, Steve sullivan and Attawith sudsang	1997	On computing four finger equilibrium and force closure grasp of polyhedral objects.	Proved the necessary and sufficient condition for equilibrium and force closure and also geometric characterization of all the types of four finger equilibrium grasp.
4	Ch. Borst, M. Fischer and G. Hirzinger	1999	A Fast and Robust Grasp Planner for Arbitrary 3D Objects	Showed that for the real robot average quality grasp is acceptable. They have also shown the statistical data that Confirm their opinion that the randomized grasp generation algorithm is fast and suitable for robot grasping
5	Jia-Wei Li, Ming-He Jin and Hong Liu	2003	A New Algorithm for Three-finger Force-closure Grasp of polygonal object.	Developed a new necessary and sufficient condition for 2-D three finger equilibrium grasp. They implemented a geometrical algorithm for computing force closure grasp of polygonal object.

Contact force: The common type of contact models assumed in the analysis of grasp and manipulation are point contact (with and without friction) and soft finger contact. A point contact without friction constrains the force applied to the body to be normal to the surface at point of contact moment to be zero [7]. In Jamia Hand, analyzing a single finger, Under-actuation spring (torsion spring) connects the lowest link to the proximal phalange, second spring connects middle phalange to proximal and third spring connects middle phalange to distal phalange. Joints are considered frictionless. Initially all the springs are in free positions. Let the torsional coefficient of spring is k_t.

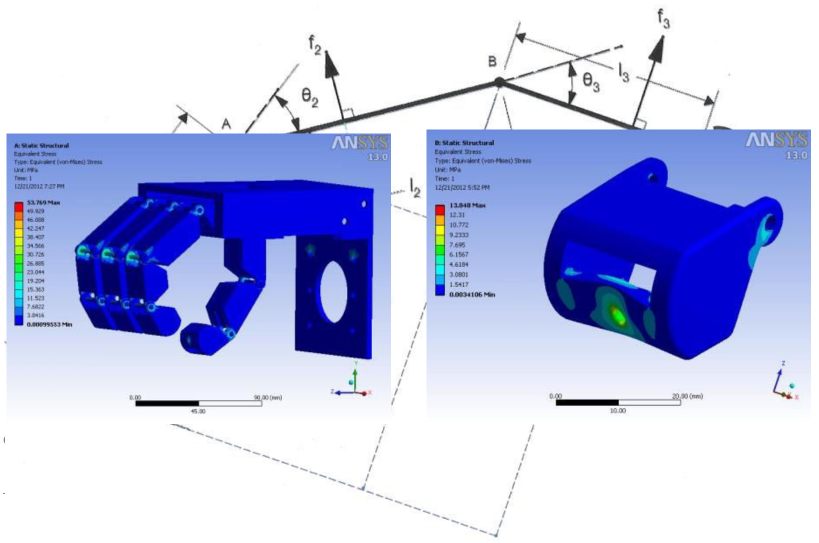


Figure 3 Free body diagram of finger

Initially when external torque is applied, link 3(distal phalange) starts rotating about joint "B" (Fig.3) and contacts the object at a distance of "r_3" from joint "B" and gets a reaction force from the object. Let the reaction force on link 3 is f_3 *and* Link 3 rotates θ_3 from its free position. Therefore, twist angle in spring 3 is θ_3.

When link 3 rotates about joint B, the spring at joint B produces a resisting torque on link 2 (middle phalange) resulting in rotation of link 2 about joint "A". when link 2 rotates, it twists spring at joint A which in turn rotates link1 (proximal phalange) about joint 'O'. The contact between link 2 and object is at "r_2", distance from A and it rotates angle θ_2 degree about joint "A" from its free position. The reaction force on link 2 is f_2. The corresponding values for link1 are"r_1" and θ_1 w.r.t. joint "O" . Reaction force by the body on link 1 is f_1.

The twisting torque due to spring on each phalange is given by

$$T_{si} = K_{ti} \,.\, \theta i \qquad \ldots\ldots\ldots \quad (1$$

i = 1, 2, 3.

External Torque due to Tendon tension T_a at Distal phalange,

$T_a = T^* b$ ……. (2)Where T is the final Tendon tension at point 7 (Fig.1) and "b" is offset distance between Tendon and Distal phalange (Fig. 6).

Applying the condition of equilibrium

$$f_1 r_1 + f_2(l_1 cos\theta_2 + r_2) + +f_3(l_1 \cos(\theta_2 + \theta_3) + l_2 \cos\theta_3 + r_3) + T_{s1} = T_a$$

………….. (3)

According to Superposition theorem "the action of a given force system on a rigid body will in no way be changed if we add to or subtract from them another system of forces in equilibrium". This theorem is used by subtracting link 3 from the system. Now link 1 and link

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