KINEMATICS OF HAND AND FINGERS DURING A REACH AND GRASP MOVEMENT

Jean-Pierre Verriest and Adriana Savescu

Université de Lyon, F-69622, Lyon, France ; INRETS, UMR_T9406, LBMC; Université Lyon 1.

25 avenue François Mitterrand, 69675 Bron Cedex, France, jean-pierre.verriest@inrets.fr

INTRODUCTION

The simulation of object manipulation tasks performed by a human operator is more and more often used to evaluate the ergonomic features of a product in the design phase. This can be done on a numerical mock-up with a numerical manikin. It requires a realistic hand model and a method to predict hand and fingers motion from the parameters describing the manipulated objects. For this purpose, an experiment was conducted to analyze the kinematics of normal reach and grasp movements performed by volunteers.

METHODS

Six right-handed volunteers (4 F, 2 M, aged 23 to 40, stature 153 to 184 cm) performed reach and grasp movements towards simple objects (cubes, cylinders and spheres) of 3 different sizes (40, 60 and 80mm) and located in front of their right shoulder at 2/3 of their maximal reach distance.

The subjects were seated with their right forearm lying on an armrest and their hand on a small dome (∅ 80mm). They were asked to reach and grasp the object in front of them, hold the position for one second and come back to the rest position at natural pace. Five grasping postures were tested for each object (force grasping with the palm and all fingers, and four precision pinching postures, opposing the thumb to 1, 2, 3 and 4 fingers).

Optical surface markers were put on several anatomical landmarks (lower and upper sternum, acromion, elbow, wrist, metacarpal and inter-phalangeal joints). The trajectories of the markers were recorded by means of a VICON® motion tracking system (12 cameras 50Hz).

The movements were reconstructed using a graphical manikin featuring a 25 dof hand [1] and whose dimensions were adjusted to each subject's anthropometry. The hand model dimensions were determined from a set of calibrated pictures of the subject's hand (Figure 1). This allowed calculating the local coordinates of the surface markers in the reference frames attached to the hand linkage. These markers were assigned to follow the 3D trajectories recorded during the movements by an inverse kinematics algorithm. Then, the evolution over time of the inter-segmental angles was available, allowing replaying the movements with the manikin (Figure 2) and calculating various quantities to characterize these movements.

RESULTS AND DISCUSSION

As an example of the results, a typical set of curves obtained during a precision grip with 5 fingers is shown on Figure 3. The four upper curves represent the time history of the distance (in mm) between the tip of the thumb and the tip of the other fingers. The lower curve represents the velocity of the hand (arbitrary units). The hand starts to open during the acceleration phase and maximum of opening is reached during the deceleration phase. Opening is larger when releasing the object.

Other geometric variables such as the position and the orientation of the hand w.r.t the object, the shape of the final approach trajectory have been calculated. The analysis will then focus on characterizing the dependency of these variables on the intrinsic (shape and size) and extrinsic (position, orientation) object parameters.

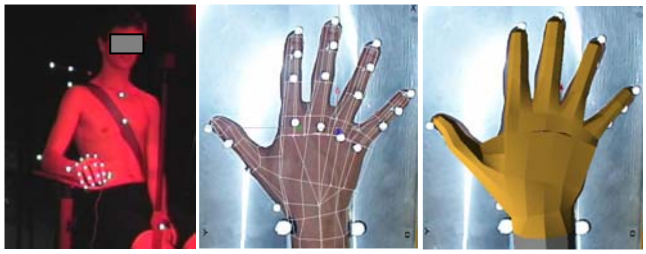

Figure 1: Subject equipped with surface markers (left). Subject's hand with markers (centre) and Manikin's hand adjusted to the subject dimensions (right)

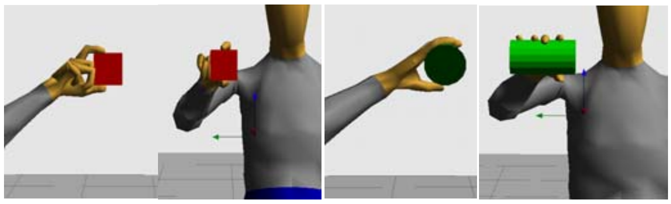

Figure 2: Two examples of reconstructed grasping movements of a 60 mm cube and of a 80 mm cylinder

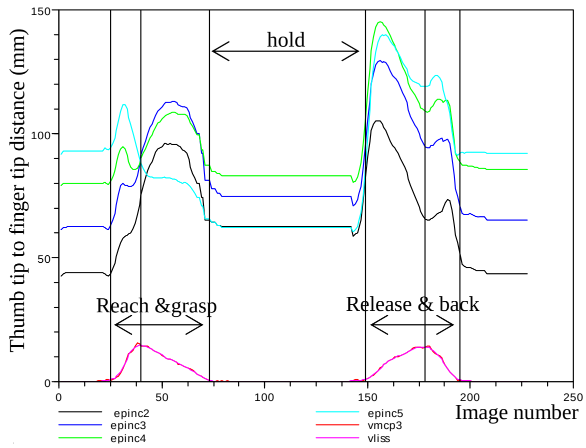

Figure 3: Time history of hand velocity and opening/closing during a 5 finger precision grasp of a 40 mm cylinder (time scale is 5 seconds for 250 frames)

CONCLUSIONS

The time and space organizational features of the 378 movements recorded will be used to derive generic rules to simulate grasping movements with a graphical manikin from a reduced set of parameters characterizing the object to grasp.

REFERENCES

1. Savescu, A.V., Cheze, L., Wang, X., Beurier, G. Verriest, J.-P., SAE 2004 Transactions Journal of Aerospace, 2004-01-219