Vision-Based Comparative Study of Analytic and Numeric Inverse Kinematic Techniques for Recovering Arm Movements

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Abstract:
The present paper compares the advantages and weaknesses of analytic and numeric Inverse Kinematics (noted IK) for computing both arms movements in a non-invasive vision-driven context. The experimental setting is the following: the performer first stands still in front of two cameras in a calibration posture for both color calibration of the hand, and skeleton estimation. Then the performer is allowed to move freely both arms while his hands' positions are tracked in real-time. Either the hand center or an estimation of the wrist position of the wrist joint center is provided to both IK techniques. Such a context is redundant as the dimension of the provided 3D position is smaller than the four degrees of freedom that can be exploited in the shoulder and the elbow. We examine how each IK technique handles this under-constrained context in terms of believability of the resulting posture and in terms of performances.

1. Introduction

Two IK methods are compared with input provided by a color tracking vision system [VBP05]. The numeric IK method is described in [BB04] while the analytic IK method extends the work from [TGB00] to ensure temporal continuity.

2. Vision-based experimental protocol and results

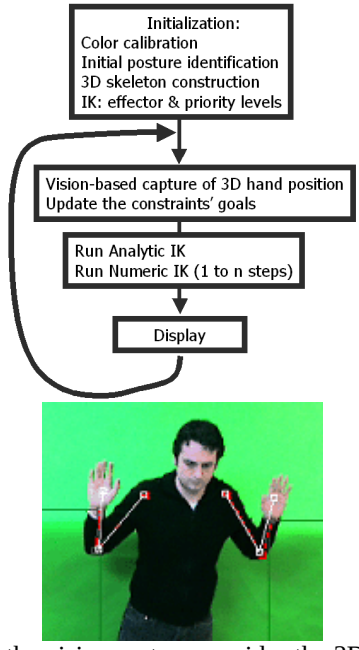

Fig. 1: the vision system provides the 3D hands position (stereo color tracking) to the 2 IK methods which in turn compute the arm posture

	Performance AMD Athlon 2800+	Continuity	Flexibility
Analytic IK	Stable 1µs 23 fps	Difficult to prevent some unstability with noisy input	Arm + leg Case by case
Numeric IK 15 dof 3 priority levels 3x6 controlled dimensions	Depends on the nb of conv. steps (+latency): 1 : 0.8µs 24fps 5 : 2.6µs 22fps 20: 8.3µs 19fps	Latency Low pass filter Coherent solution with attraction towards initial positions	Generic Can be extended to spine and full body

3. Conclusion

Our current results show the maturity of numeric IK in real-time context. Its computing cost is equivalent to analytic IK while offering a greater potential in terms of stability and flexibility. Future work will extend the study to movements including the torso.

References

[BB04] Baerlocher P., Boulic R., *"An Inverse Kinematic Architecture Enforcing an Arbitrary Number of Strict Priority Levels"*, The Visual Computer, Springer Verlag, 20(6), 2004, 402-417.

[TGB00] Tolani D., Goswami A., Badler N. *"Real-time inverse kinematics techniques for anthropomorphic limbs"*. Graphical Models and Image Processing, Elsevier, *62-5* (Sept. 2000), 353-388.

[VBP05] Varona J., Buades J., Perales f.J., *"Hands and face tracking for VR applications"*, Computers and Graphics, Elsevier, 29-2 (April 2005), 179-187.