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FULL BODY ADJUSTMENT USING ITERATIVE INVERSE KINEMATIC AND BODY PARTS CORRELATION

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In this paper, we present an iterative inverse kinematic method that adjust 3D human full body pose in real time to achieve new constraints. The input data for the adjustments are the starting posture and the desired end effectors positions -constraints-. The principal idea of our method is to divide the full-body into groups and apply inverse kinematic based on conformal algebra to each group in specific order, our proposed method involve correlation of body parts. In the first part of the paper we explain the used inverse kinematic when handle with one and multiple constraints simultaneously and in the case of the collision induced by the joints with the objects of the environment. The second part focuses on the adjustment algorithm of the full body using the inverse kinematic described above. Comparison is made between the used inverse kinematic(IK) and another inverse kinematic that have the same principle. In the case of multiple tasks simultaneously, our inverse kinematic gives results without conflict. With presence of obstacles, our IK allows to avoid collisions too. Preliminary results of the adjustment method show that it generates new realistic poses that respect quickly new constraints. The tests made on our adjustment method show that it resolves the motion retargeting problem.

Keywords: Animation, Inverse kinematic, Geometric algebra, Virtual humanoid

1 Introduction

In many fields such as robotics and animation, there is often a need to control articulated structures in complex conditions. In the animation case, the control may involve posing the character body or some kinematic chain of the character to respect new constraints. Constraints may be defined as end effectors targets or goal positions. In this paper, we refer to reaching the goal position by task.

Character body is represented as series of different poses of rigid articulated chain, consisting of set of segments connected by joints. The joints correspond to articulations such as elbow, wrist, sterno-clavicular while the segments correspond to the body limbs such as the upper arms, forearms... Each joint have one to three degrees of freedom (DOF) that represent the rotation angle of the joint relative to its joint parent, the character body root is generally in the pelvis. The root position/orientation and the joint rotation represent character pose configuration. To generate new pose with known goal position where the new goal position may be the desired end-effector position or any other desired joint position. Inverse kinematics (IK) is one of the most important used techniques in which methods tend to compute the joints angles in the aim of moving the end effectors as close as possible to the desired position.

1.1 Motivation

The focus of this research is aimed to moving away from recent character pose adjustment using the data-driven inverse kinematics which need an important quantity of motions [17, 18], towards an online method that can provide realistic character poses. This method can be used in many field such as in the motion editing and the motion retargeting field to edit the motion to fit some constraints or even in the robotic field to perform task. The main contribution of this paper is to propose pose adjustment by:

(i) Dividing the character body into groups and apply IK to each group,
(ii) Using inverse kinematic method based on FABRIK method, our method differ to the original FABRIK method in the following points :
  (a) It minimizes the number of moved joints to reach targets,
  (b) It uses the priority to avoid conflicts between tasks,
  (c) It avoids obstacles while positioning end-effectors
(iii) Involve correlation of body parts.

The present paper is structured as follow: in the first section, we review related work on the inverse kinematic, then we discuss IK methods, their advantages and drawbacks. In the second section, we present an overview on the proposed method that allows to adjust the full-body to new constraints. In third section, we present the inverse kinematic used in the adjustment method for one and multiple constraints and in the case where there is other objects in the environment. In the fourth section, we present our character model and we introduce the steps of proposed adjustment method. In the last section we start with comparison between our proposed inverse kinematic method and another method that have the same principle (FABRIK), next we present preliminary results of our adjustment method and an application of the proposed method to solve the motion retargeting problem.

2 Related work

The inverse kinematic problem is well studied. To handle simple kinematic chain that contains a few degrees of freedom, the analytical methods are the best choice [5, 4]. These methods are fast but they do not give solution in the complex articulated figures case. Numerical methods based on Jacobian matrix [6, 2] are proposed to deal with complex articulated figures. These methods tend to be computationally expensive. Moreover, they suffer from singularities due to the matrix using. To overcome the high computational time, heuristic method are proposed such as CCD (Cyclic Coordinate Descent) [3, 7] and triangulation [8]. The advantage of those methods is that they are computationally very fast. However they do not support multiple tasks control. Kulpa in his work [9] tried to give solution to reach multiple task simultaneously by dividing the whole body into groups and apply CCD method [3] to each part separately. Another heuristic method called "Forward and Backward Inverse Kinematic" (FABRIK) proposed by Aristidou & Lasenby [1] to the hand modeling and traking, it is based on geometric algebra to resolve the inverse kinematic problem. A comparison is made in [1] show that FABRIK method is fast than other inverse kinematic methods. The FABRIK method can handle with angular limits. However, it presents conflicts when dealing with multiple tasks. Beside, FABRIK is for unconstrained environments, hence it does not give good results in the collisions case. Recently, an inverse kinematic methods that work in the distance space are proposed [2]. A general problem of IK algorithms cited above is the difficulty to ensure the naturalness of the generated pose. This is because natural human motion involves correlation of body parts. Data driven IK systems have been presented as in [17, 18], those methods are based on training data and create model, they can generate natural pose but poses are highly related to the training data and require huge database. Furthermore, Huang and Pelachaud, [20] they used a mass-spring model to adjust the joint positions by minimising the force energy which is conserved in springs to solve the inverse Kinematics problem from an energy transfer perspective.

The character control usually requires that we simultaneously apply multiple constraints and manage multiple tasks [9, 1], which may lead to conflicts between tasks because some are not achievable at the same time. An efficient inverse kinematic must have strategy to deal with this problem. To treat this problem, some solutions are based on attributing weight to each task to define their relative importance [10, 11] and solve the problem as a multi-objective optimization where no task is achieved exactly but the sum of errors is minimized. Other solution is based on "task priority". Priority based method as in [13] tend to sort the tasks by order of priority, in order to satisfy the most important task first, the method in [13] can deal with two tasks in the same time. Well known method in the priority task method is PIK "priority inverse kinematic" [12] where it can handle with many constraints.

The basic IK methods compute character poses in an obstacle free space. However most environments are not obstacle free. This means that the inverse kinematics method should give result without joint-obstacle collision. Many studies have been reported on the obstacle avoidance problem. To deal with this problem two steps are needed, firstly "collision detection" where we detect when and where the joints collide with the obstacles, the second step is "collision response". Our main focus is in the second step. Many studies have been reported on the collision response problem in the animation and robotic domain. The Path planning methods are mostly used in the animation [14, 15]. However, they are moreover computationally expensive. Aside, the path planning method is not useful for the real time motion control. In [19] are used for collision response for virtual human limbs, they treat self-collision meaning that the arms and legs do not collide with other body parts of the virtual character. In this method the authors treat the collision between the character arms and legs. Nevertheless, this method is only useful when there are no other objects present and self-collision is the only element to consider

3 Overview of the proposed method

Figure 1 shows an overview of the proposed method in which the character is divided into five groups that correspond to the legs, trunk, arms and head. The groups are connected by two joints, root and sterno-clavicular, this connection ensure the correlation or synergy between the body parts, more detail to the subdividing step is explained the "character model" section . The subdividing of the body has the advantage to ease the adjustment, while creating the synergy between the body parts ensure the realism of the adjustment result. To adjust pose to new constraints using our method, it should have as input the initial character pose, the constrained joints and their desired positions. In the first step, the root and the sterno clavicular configuration -position/orientation- are calculated based on the desired positions. Then, the proposed inverse kinematic are applied to each group by order to respect the constraints. In addition, to get more realistic pose, we may at each inverse kinematic iteration set the joints biomechanical limits in case it is necessary, to respect the biomecahnical limits of each joints, we will use the same principle as in [1].

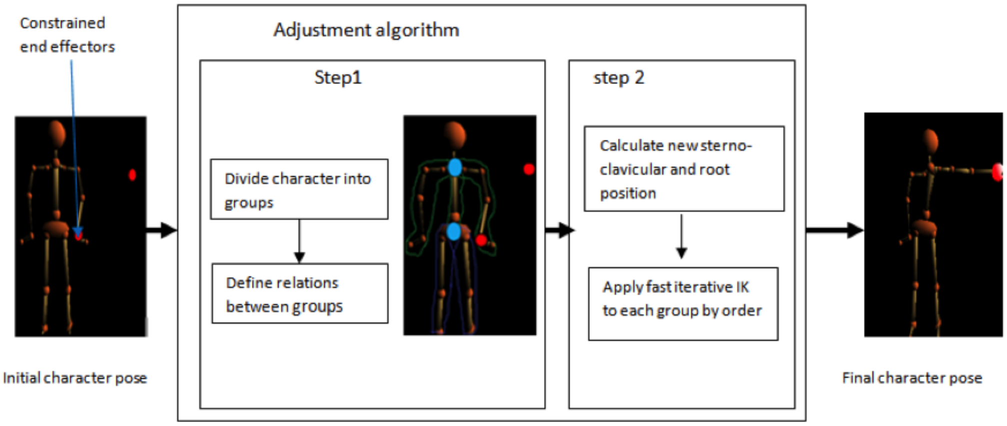


Fig. 1. System overview

4 Iterative IK

Our inverse kinematic has the same principle as FABRIK [1]. Hence, it has two steps: Forward and Backward. New joint position is calculated by keeping constant the length between $joint_i$ and $joint_{i-1}$. Nevertheless, we propose algorithms to handle with environment obstacles and conflict between tasks. The flowing sections represent the proposed idea.

4.1 Obstacle avoidance

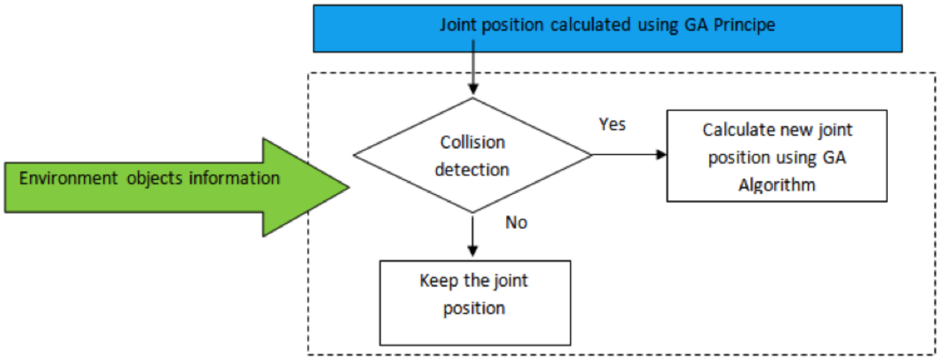


Fig. 2. Obstacle avoidance processes

It aim to ensure that the character joints do not collide with static or dynamic objects (obstacles). static objects represent objects that do not move, while the dynamic objects represent objects in motion. The strategy to avoid collisions must be integrated within the IK algorithm. Our proposition is based on geometric algebra (GA) to calculate the joints positions (figure 2). Using this algorithm, we keep the rapidity of our IK, which may be useful in the interactive applications and fits with the iterative and local nature of the method used for the inverse kinematic. Our proposed algorithm has two parts: detection and collision response (figure 3). In the case where the character and the objects are in motion, we apply the algorithm to each frame.

4.1.1 Collision detection

In this step we need to detect if the joint collide with the obstacle. There is many collision detection methods, our detection algorithm uses Aligned Bounding Boxes (AABB). It consists to encapsulate the environment objects with simple geometric forms as cubes and spheres, then tests if a specific joint is in intersection with ABB or not. AAB simplifies the resolution of intersection problem of complex forms.

4.1.2 Collision response

The basic inverse kinematic is position based local method. The new joint position depend on the previous calculated joint position. Our proposition acts differently: the new joint position does not depend only on the previous calculated joint position, but it depend also on the obstacle position. In the inverse kinematic obstacle avoidance algorithm, we calculate the new $joint_i$ position while keeping the distance D between $joint_i$ and $joint_{i-1}$. We define pos_i as this new position. If the $joint_i$ in $pos_i(x_0, y_0, z_0)$ collide with an object then we calculate new position $pos_i^{'}(x, y, z)$ for this joint, else we keep this position and we calculate the next joint position. $pos_i^{'}$ must respect two distances: D and $dis_{max} + \triangle d$. dis_{max} is the distance between the $joint_i$ and the bounding box edge and $\triangle d$ represent security value (chosen equal to 0.01). To respect the both distances, we used geometric algebra notions (GA). In this field, to calculate the new joint position where we know the $joint_i$ and $joint_{i-1}$ positions, can be achieved by intersecting two spheres where the first sphere center is $pos_i(x_0, y_0, z_0)$ and its radius is dis ($dis = dis_{max} + \triangle d$), the second sphere center is $joint_{i-1}$ (x_1, y_1, z_1) and it's radius is D. The two spheres intersection involves to solve the system of equation (1).

$$\begin{array}{c}(\text{x-x}_0)^2 + (y - y_0)^2 + (z - z_0)^2 = dis^2 \\ (\text{x-x}_1)^2 + (y - y_1)^2 + (z - z_1)^2 = D^2\end{array} \tag{1}$$

The solution of the equation system (1) is a circle. As we need to get one point that will be the new $joint_i$ without collision, we propose to fix the z coordinate, and because we have the sum equal to D^2 where $dis^2, (z - z_0) or (z - z_1)$ should not exceeds the radius. We used equation Eq2 to fix z.

$$|z - z_1| < Det|z - z_0| < dis \tag{2}$$

To find the new position $pos_i^{'}(x, y, z)$ of the $joint_i$ of the actual position $pos_i(x_0, y_0, z_0)$ we must solve the following equation system:

$$\begin{array}{lcl} (\text{x-x}_0)^2 + (y-y_0)^2 + (z-z_0)^2 & = & \text{dis}^2 \\ (\text{x-x}_1)^2 + (y-y_1)^2 + (z-z_1)^2 & = & \text{D}^2 \\ |z-z_1| < D \; et \; |Z-z_0| & < & \text{dis} \end{array} \qquad (3)$$

The proposed algorithm to find new joint position without collision with an obstacle is summarized in the the following pseudo algorithm:

Obstacle avoidance algorithm

```
Input     pos$_i(x_0, y_0, z_0\ )$, $joint_{i-1}(x_1, y_1, z_1)$
          Objects list
Output    new joint$_i$ $position\ :\ pos_i^{'}(x, y, z)$
Check the intersection between joint$_i$ and the environment object
If there isn't intersection
      Do nothing and keep pos$_i^{'}(x, y, z)$ as joint$_i$ position
else
      Calculate the distances between joint$_i$
            and the bounding box corner $(d_1, d_2, ..., d_n)$
Calculate $dis_{max} = max(d_1, ..., d_n)$
Calculate z using equation (3)
Calculate x,y resolving (1) and (2)
```

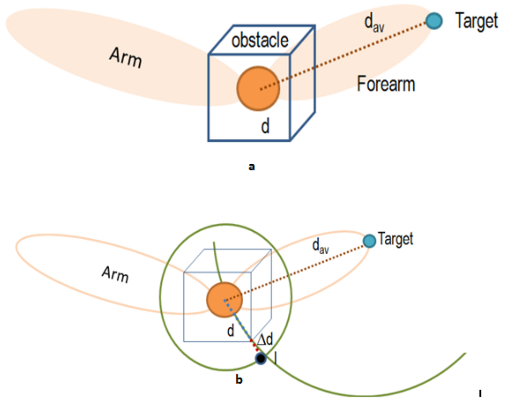


Fig. 3. Obstacle avoidance using geometric algebra(GA): The elbow collide with an object (a), after applying the obstacle avoidance algorithm, the elbow don't collide with the object

4.2 Multiple task

It is essential for an IK solver to be able to solve problems with multiple targets. However, without good strategy this may lead to conflict between tasks. In our proposition, the character is subdivided into groups. Those groups are connected between them by sub-base: root and streno-clavicular. Based on the work of Boulic [12] we propose to assign a priority to each task. To get the position of the sub-joints two variants are proposed. We propose two variants, because in some cases we have to verify the height priority task (foot on the ground) and in some other cases it is preferable to reach the highest priority task more then the lower one. We use those variants to calculate the new sub-joints position.

4.2.1 Variant 1

To get the new joints position we apply the forward stage for each group, at the end of this stage, many new sub-base positions are presented as the number of groups. The new sub-base position is calculated using the following equation

$$newpos = \frac{\sum_{i=1}^{i=n} pos_i \times priority_i}{\sum_{i=1}^{i=n} priority_i} \tag{4}$$

Where Pos_i is the sub-base position for the group i and $Priority_i$ is the task priority of the group i. Using the priority notation, the task that is more important will be achieved before the lowest ones.

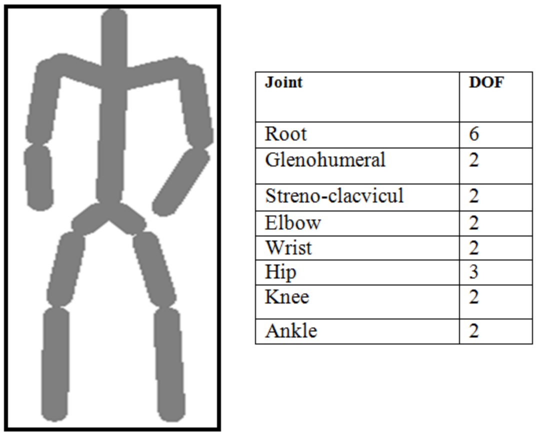
4.2.2 Variant 2

In this variant, we sort the tasks by the order of priority. We obtained numerous simple chains, then we apply the previous algorithm for each simple chain, starting by the low priority chain to the high one. Starting by the task with low priority ensure that the task that have the highest priority will be reached much as possible.

5 Adjustment using inverse kinematic

5.1 Character model

The structure of our character model consists of rigid kinematic chain (cylinders) connected by angular joints (figure 4).



Joint	**DOF**
Root	6
Glenohumeral	2
Streno-clacvicul	2
Elbow	2
Wrist	2
Hip	3
Knee	2
Ankle	2

Fig. 4. Character model:proposed hierarchy

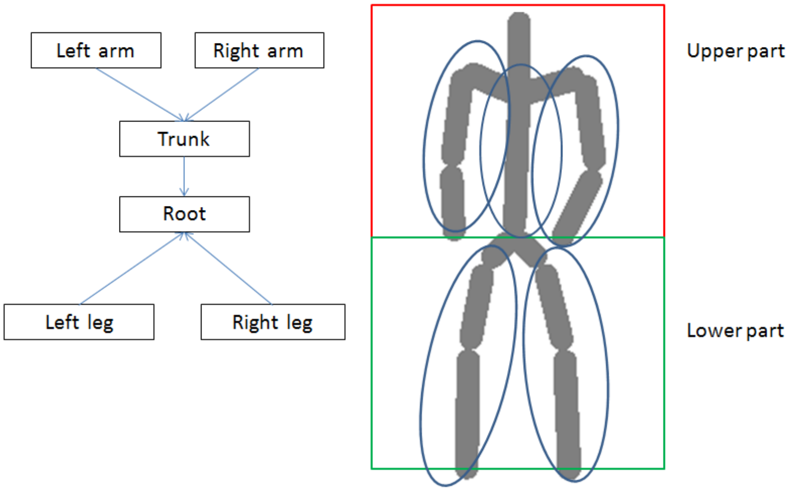


Fig. 5. Character representation :dividing the character onto groups

As in the work of Shin [16] where the character is subdivided into groups and analytic inverse kinematic is applied to each group, we use almost the same principle. The figure 5 represents the character model. We decompose the humanoid in two parts and five groups. The arms and trunk are linked by the ”streno-clavicular”, where the change in one arm configuration may affect change in the other arm and that may affect even the trunk configuration. Beside, The legs and the trunk are linked by the ”root”,changing one leg configuration involve change in the root configuration and the other leg. To more explain this correlation, suppose we want to move the left foot to be in desired position, while this desired position is far from the leg, to reach this task we may change in the root position, this changing affect another member that is the other leg configuration. Re positioning/rotating the root involve change in the all the groups configuration. This representation allow to ease the humanoid control. After the subdividing we apply our inverse kinematic to each group. Using the inverse kinematic to subdividing groups make the adjustment method very fast. We apply just the joints of the group concerned by the motion.

5.2 Full body adjustment

The main idea of our adjustment approach is that the adjustment is solved sequentially using simple iterative IK based on geometric algebra on different parts of the body and in specific order. No motion database is necessary. Based on the desired end-effectors, the root and sterno-clavicular configurations are calculated. The trunk joints orientation are calculated based on the new root and sterno-clavicular configurations. Finally, each of the limbs configurations is determined based on the new clavicle position for the arms, the new root position for the legs and the end-effectors positions with an iterative IK. Algorithm 1 summarizes the proposed method.

Algorithm 1

```
input : starting character pose,  desired end-effectors position
output : new character pose
1-Calculate the new root, sterno-clavicular  position based on
   the desired end-effectors positions
2-Trunk adjustment,  using new sterno-clavicular position
3-Arms adjustment
4-Legs adjustment
end
```

5.2.1 Calculate the new root sterno-clavicular position

To reach an object, in real human motion it is preferable to solicit the trunk only when it is impossible to achieve the target by moving just the arm. To achieve the natural pose, we inspired our proposition from the real life. We first verify the contribution of the trunk and the root in the arm or leg motion to satisfy the constraint, and then calculate the new trunk configuration.

To test the contribution of the trunk in the motion, we calculate the distance D between the sterno-clavicular and the target if its lower than the arm length, the sterno-clavicular and the root keep their original positions 6.

In the opposite case, where the target is placed beyond arms length, the trunk chain is integrated in the arm transport. In this case, the new sterno-clavicular position/orientation $Pos^{'}$ in order to get distance between target and this position equal to the arm length.

In some cases we cannot move the trunk in order to be the sterno-clavicular in pos' (the target is very far) one solution is to move the pelvis by error distance to be in $pos^{'}_{pelvis}$. The error distance in the pelvis position is calculated using the distance between the actual position of the pelvis and the actual sterno-clavicular position, and the distance between the actual sterno-clavicular position and $Pos^{'}$.

In the case where there are two tasks to be achieved, user can choose between the two variants in order to calculate the sub-joint positions. In the case where both arms are constrained the new trunk configuration is calculated considering the sterno-clavicular joint as the sub joint between the two arms. The new sterno clavicular position is calculated by choosing one variant from the variants described in section 4.2. If there is no variant chosen we calculate the new sterno-clavicular position using equation (1). In the default case to calculate the root position where there are constraints on the upper and lower body the root position is calculated using variant two where the lower body constraint have the highest priority.

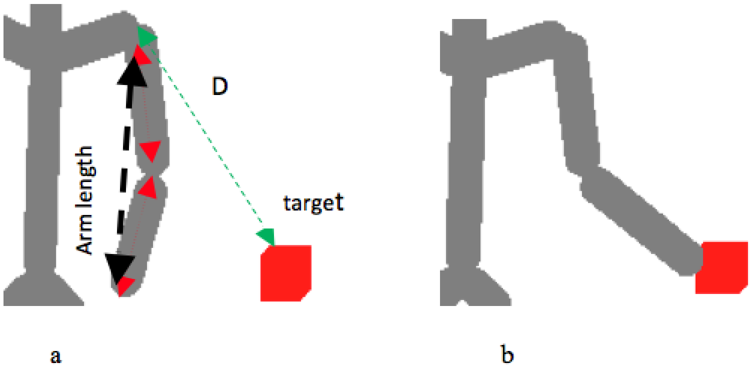


Fig. 6. Reach target in simple chain. Figure *a* presents the initial arm configuration where we calculate the arm length and the distance target-end effectors, in figure b we move just the arm because the arm lenghth is lower then the distance between the target and the end-effectors

5.2.2 Root adjustment

Based on the sterno-clavicular and Ankles desired position we determine the new root position. The ankles positions are given high priority. The new root position is calculated using variant two in the sub-section 4.2. we choose this variant because the new root position must verify strictly the ankles position.

5.2.3 Trunk adjustment

For the trunk adjustment, our inverse kinematic is applied on the trunk chain. The trunk is constructed from five joints represent the most important spines. The root of the trunk chain is the character body root and the end effectors are the sterno-clavicular. The aim of this step is to find the new joints trunk position/orientation based on the sterno-clavicular configuration.

Algortihm 3

```
Input :target position,  initial  trunk configuration
Output : trunk configuration
1- D1=|sterno-clavicular position-wrist position|
2-D=|sterno-clavicular position-object position|
3-If (D1<D) new sterno-clavicul position is calculated
            Apply IK to find the new trunk configuration
End
```

In the case where both arms are constrained, the new trunk configuration is calculated considering the sterno clavicular joint as the sub joint between the two arms. The new sterno clavicular position is calculated by choosing one variant from the variants described in section 4.2. If there is no variant chosen we calculate the new sterno-clavicular position using equation (1). After getting the new position we apply IK to the trunk chain to get the new trunk orientation.

5.2.4 Upper and lower body limbs adjustment

Now the configuration of the trunk and the root has been determined, we apply inverse kinematic to adjust the arms and the legs to their corresponding desired end effectors positions.

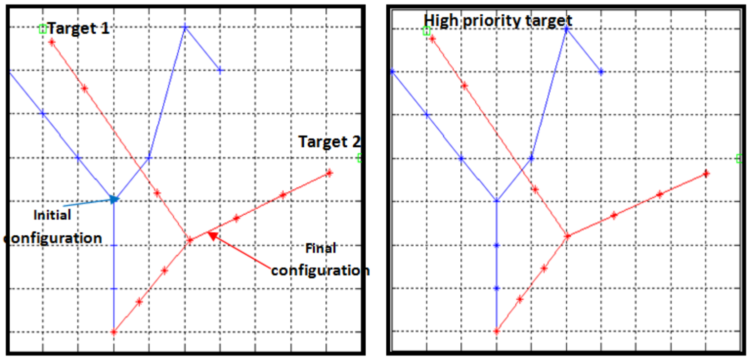
For the arm limb, the root of the inverse kinematic is the sterno-clavicular position. While for the legs, the root of the applied inverse kinematic is the pelvis.

6 Results

In the result section, we first compare our inverse kinematic with FABRIK method that have the same principle, then we will give some preliminary results of our adjustment method and the application of our adjustement method in the motion retargeting field. All the tests are made in intel(R)Core(TM)i3-2330M CPU @ 2.20 GHZ and windows7 as operating system machine.

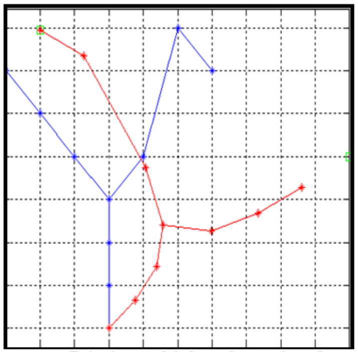
6.1 Comparison of our IK to FABRIK

6.1.1 Priority inverse kinematic



a- FABRIK method

b- Priority multiple task –variant 1-

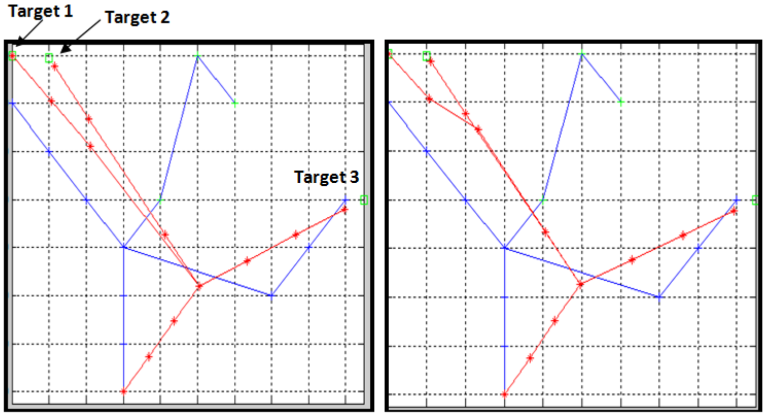


c- Priority multiple task –variant 2-

Fig. 7. Multiple tasks case

In this subsection we implemented our priority inverse kinematic and FABRIK using matlabR 2011a as programming language. The Figure fig:result11 represents three chains connected by sub-base with two end-effectors and two desired positions. In the character case, those chains represent arms and trunk. This figure aims to represent how deal our inverse in the presence of two target in the same time compared to FABRIK. Figure (7).a represents the result when applying FABRIK to the chains, as shown there is conflict between tasks. When we apply our inverse kinematic to the chains in the figure (7).b the height priority target is achieved without conflict.

The Variant1 result depends on the priority value of each task, thus the choice of the priority value is very important, a wrong choice may achieve the high priority task but in high computational time. While in the second variant the result depends only on the high priority task. As conclusion, variant2 is used when the high priority task must be completely achieved as it's possible to get more than two tasks to achieve we tested the algorithm when deal with three tasks.



a- FABRIK method
Time=0,4
Iteration number=426

b- Priority multiple task –variant 1-
time =0.06
iteration number=71

Fig. 8. Three tasks case: using the priority multiple task we need less processing time and fewer iterations to reach the targets comparing with FABRIK.

In the figure (8) we tested and compare our method and FABRIK method when dealing with three tasks we obtained noteworthy results. When we apply FABRIK for three end effectors (figure 8).a the number of iteration is very height and we consummate high time to achieve the targets. In the figure (8).b can see that when we apply FABRIK with priority the number of iteration is reduced and the computational time too.

FABRIK needs 426 iterations and just 0.4s to attain three targets, where there is two targets are not reachable and another is reachable, while using the priority stategy we need just 71 iteration and 0.06s to reach the first two high priority target(tasks).

Comparing with Kulpa's work, Kulpa in his work he based on CCD inverse kinematic, as our method has the same principle as FABRIK that is fast then CCD, we implies that our inverse kinematics is fast than the kulpa's method.In the author side, as no synergy exists between groups in kulpa's method, it may lead to unrealistic results in our work work we avoid this problem by taking in account the correclation between the body parts.

6.1.2 Obstacle avoidance

In this section and to prove the efficiency of the obstacles avoid subtask, (figure 9)-a represents chain with five joints that represent an arm it is implementing using OGRE3d and visual c++, the arm end-effectors have to reach the target (red object) while there are obstacles in the environment (blue and green objects). When we apply FABRIK to reach the target the joints arm collide with the other objects in the environment (figure 9)-b. But when applying our inverse kinematic with the obstacle avoidance test, (figure 9)-c represents the result: the end-effectors reach the target without collision with the obstacles. to improve the realism of the pose result, we apply the joint limits algorithm respect the biochemical limits of each joint.

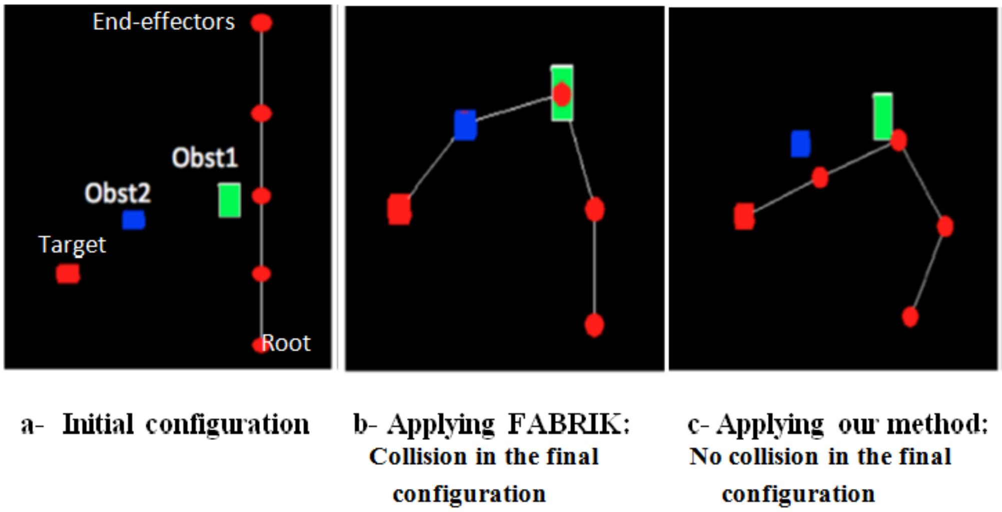
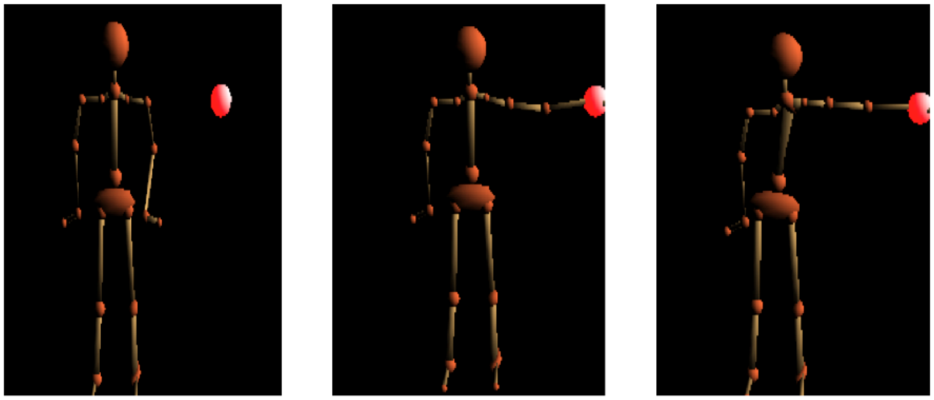


Fig. 9. Obstacle avoidance

6.2 Preliminary adjustment method results

6.2.1 Reaching objects

In the first two result subsections, we tested the reliability of our inverse kinematic in independent chains. Finally, in this section we test the adjustment of the full body method. Figure 10.a represents the character initial pose, the task is to reach the red object. Applying the algorithms 1 and 2 we reconstruct the full body pose. In the first case (figure10.b), the target is close to the character so the trunk keep its initial configuration and just the arm changes its configuration. This is natural pose because in real life when the target is close we use just the arm to reach it. We made another test where the target (figure10.c) is far from the character, in this case the trunk moves to help the arm to reach the task.



a- initial configuration b- reach target just by moving arm c- including the trunk to reach target

Fig. 10. Reaching objects

6.2.2 Multiple constraints

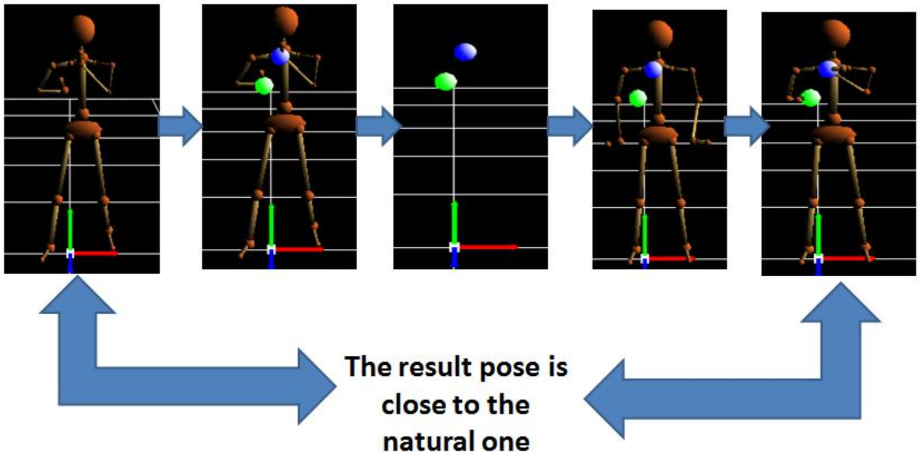


Fig. 11. Multiple tasks case1

To discuss the performance of our method, in figures 11 and 12, we compare the adjustment method results to a natural captured pose. In the first case (figure 11) we will use an arm end effectors of an natural pose as the desired goal position

To test the adjustment we follow two steps:

1. We recover the arm's end effectors positions from natural pose figure 11(a-b) then we represent them as spheres,

2. In the other side, we have character in an initial pose, we apply the adjustment method to it in order that arm's end-effectors reach the spheres. Figure 11(c-d-e)

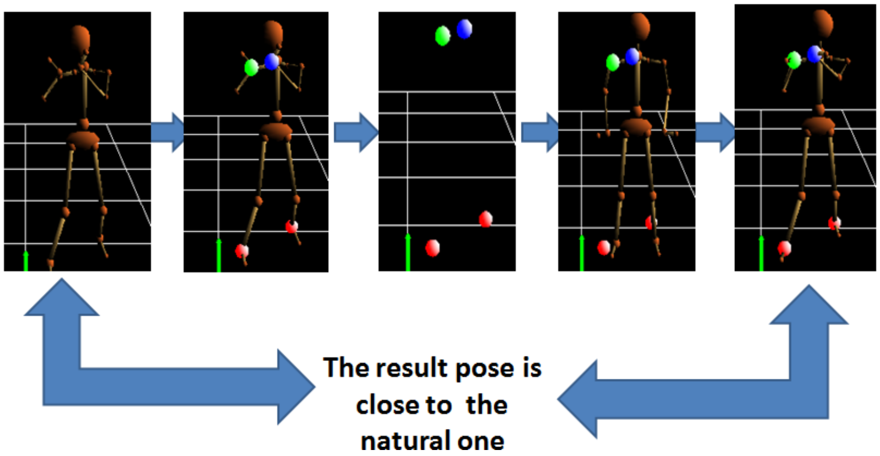


Fig. 12. Multiple tasks case2

In the second case, there are four tasks to reach. We recover the arm's end-effectors position and the leg's end-effector position from natural pose figure 12(a-b) then we represent them as spheres. We apply the adjustment method to our character that is in it's initial pose in order that their four end-effectors -arm's and legs end effctors- be in their desired positions. Remarkably, the adjustment result is very close to the natural pose.

Table 1. Comparison between natural and our method's pose

Angle	Natural pose	Our method's pose
Ang1_Arm1	0.5311	0.5551
Ang2_Arm1	0.0003	0
Ang3_Arm1	1.4031	0.3182

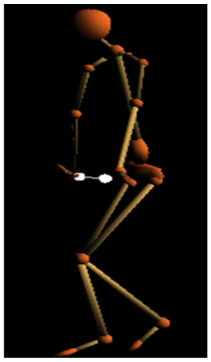
Table 1 represents comparison between the arm's joints angle of natural pose and the adjustment pose where they have the same arm's end effectors position. We calculate the angles between the arm's joint in radian in the both case. As we see the arm's joint angle of the natural pose and our pose is almost equal.

6.2.3 Motion retargeting using adjustment method

Due to the good results of the adjustment method, we used it in the motion retargeting problem to adapt the end-effectors positions to their desired positions in order to respect environment constraints. One of the main problems in using motion capture data to animate characters is the problem of retargeting, the motion data is not applicable for other skeleton and other environment. To facilitate its use, the motion must be edited to meet specific environmental constraints and/or character proprieties. To solve this problem we apply our adjustment algorithm to preserve the original motion constraints, as the position of the end effectors. Figure 13.a represent character pose from motion file, while the character reach an object. Nevertheless, in the figure 13.b we apply the same data to another character that have not the same segment length; the character can't reach the object. Applying our adjustment method we adapt the motion data to the new character and the character reach the object.

a-Apply motion data to an initial character: character reaches an object

b- Apply motion data to a larger character: character don't reach the object



c- Apply motion data and the adjustment algorithm: character reaches the object

Fig. 13. Motion retargeting using adjustment method:the adjsutement method is used to adapt motion data to new morphology

7 Conclusion

In this paper, we propose a new fast method for pose adjustment to new constraints. The principal idea of the method is to divide the character body into groups and apply an iterative inverse kinematic to each group in a specific order. The used inverse kinematic method have the same principle as FABRIK where it uses geometric algebra principle to solve the problem. Comparing our inverse kinematic with FABRIK, our IK controls multiple end-effectors without conflict by assigning priority to each task. Beside, the used inverse kinematic method solves the problem without collision between joints and the environment objects. Adjust the character body to the new constraints following algorithm 1 has two advantages. Dividing the character body into groups, that has the advantage to make easy the computation of a solution. As there is synergy between the groups, where the adjustment of the groups follows an order and consider the other groups actual and desired configuration, the body pose is realistic.

In our work, we are taking into account just the kinematic side to adjust the character pose to new constraint. But, taking just kinematic constraint into consideration may give us unrealistic poses. As a future work, we plan to maintain the pose balancing to get more realistic poses by combining the inverse kinematic and the kinetic in the same algorithm. Beside, in this paper we presented full adjustement algorithm for one pose. As a future direction, we would like to sue our method to adjust pose that is part of motion taking into account the other frames.

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