

Ex Machina: Rigging Beneath The Surface

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Figure 1: Initial plate vs. final render of Ava, showing body-tracked replacement of surface and internal mechanisms. Photo credit ©A24

Abstract

One of the biggest visual effects challenges of independent sci-fi thriller *Ex Machina* was the development of a fast and flexible rigging solution for central android character *Ava*. It needed to be able to withstand a large degree of on-set costume-fitting variance, and facilitate the precise tracking and CG replacement of multiple body-sections, under the full scrutiny of being able to see right 'under the skin' to her internal structure and mechanisms. Our approach combines multiple levels of base-humanoid and custom rig modules with a series of multi-layered skin-clusters, utilising a mixture of joint and geometry-based skin-influences. The result is a very organised and adaptable rigging solution that gives tracking artists both a broad and fine level of control over each body-section, with minimal sacrifice of speed. This work builds on our knowledge and experiences from tracking the 'Synth' police robots on the recent remake of *Total Recall* (2012).

1 Costume Fitting

There were 4 different versions of *Ava*'s physical costume to allow for easy on-set maintenance, with natural variance between them and a slightly different fit each day. The black rubber 'join bands' around her upper-arms, wrists, upper-legs, ankles, waist, breast, and neck were designed, along with the face-edge and neck prosthetic, as natural crossover points between the CG and live-action plate. Matching these areas would be critical to the success of our body-tracks.

We conducted some early rigging tests using base-humanoid modules in *Pinocchio*, Double Negative's in-house procedural rigging system, to mock up a series of rendered still images with reference plates shot on-set. Based on this first official fitting, we added two layers of custom mini-rigs for the black 'join band' and white inner-cuff areas, to be able to broadly scale and translate them, and fine-tune sculpt their meshes. A mesh-sculpt ability was also added to the face-edge and neck prosthetic.

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We tackled each area of the body and applied similar layered abilities as required. The result was a highly flexible rig that could be matched to any variation of costume-fitting, and literally sculpted into position if necessary. All of these controls were fully animatable to help track any small costume movements, including stretches and pulls.

2 Surface vs. Internals Tracking

For some areas it was important to have independent control over the underlying internals in addition to the standard surface controls. On a very flexible area such as the neck, any slight misjudgment in the z-depth of a head-track might look fine on the surface, but would usually result in sudden pops of the spine and other internal neck structures, due to the natural 's-bend' of the inner rig-joints. Similarly, being able to see right into the legs meant that the action of *Ava* sitting down was also very unforgiving, with nowhere to hide any contact intersections. This required us to rig a proper 'high squash' ability for the leg internals, taking into account the surface, rigid inner-parts, and flexible muscles and tendons.

3 Fine-Tuning

To fine-tune the arm and leg 'join band' tracks we layered in some additional 'tweaker' offset and rotate-shear controls. The upper-arms in particular needed this functionality to counter the difficulty of tracking them from a shoulder-based pivot. These controllers were given a multiplier effect so their values could be factored down to enable very precise hand-tracking. This proved invaluable for tightening up tracks on the majority of our shots, as the aesthetics of the film dictated very soft lenses with a shallow depth of field, and focus fall-offs around the edges of frame.

We regularly encountered 'knee jitter' issues when tracking *Ava* walking, due to the very gentle and controlled, almost balletic, nature of her movements. To address this we created a completely off-the-wall rigging solution called 'CrazyIK', a leg rig with an IK ankle and an FK thigh, joined together by an auto-stretching lower-leg. This combination of FK and IK completely removed the problem, by effectively hiding any jitter in tiny scalings spread across the lower-leg, and allowed us to non-destructively fix a two-week problematic track in less than half an hour.

Overall, our rig was very successful at enabling the body-track team to complete the challenge of accurately tracking the multiple body-sections, with a far greater level of flexibility and control than on previous shows.