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Deformable Surface Tracking and Alpha Matting for the Automation of Post-production Workflows

D2.1: Use case definitions

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Public executive summary

This deliverable provides an overview of the most important use cases for deformable surface tracking and alpha matting in postproduction and visual effects workflows. It is based on the knowledge and experience about real-world productions of the project partners Moto (MOT) and Digital Graphics (DG) and other visual effects companies which have been also consulted.

The report does not only discuss use cases where either tracking or matting tools are used, but also use cases where both tools are required to fulfill a certain task. Each of the use cases is discussed in a general way and illustrated with one or two examples which may be used for evaluating the developed tools later in the project.

1. Introduction

The goal of this deliverable is to review and describe the most important use cases where efficient matting and tracking tools are required for visual effects. The use cases presented in this document are derived from common visual effects tasks and actual projects that have been executed by post-production companies with the use of established "off-the-shelf"-tools. While larger companies with substantial R&D resources might have developed in-house tools to solve these problems, smaller companies usually have to rely on standard tools from their software packages and techniques based on best practice and experimentation.

The use cases have been defined by the post-production partners of the AUTOPOST project MOTO and DG. In order to come up with a representative list of use cases the partners have further exploited their established world-wide connections by collecting and discussing use cases with external partners.

Following the task based separation from the proposal, this report discusses use cases for surface tracking (section 2) and use cases for alpha matting (section 3) independently. Since there are various use cases where both matting and tracking are used, section 4 discusses mixed use cases which may benefit from an interaction between the two tasks. Finally, section 5 provides a summary of the use cases and an outlook on the next steps.

1.1 Surface tracking

Changing the appearance of inanimate objects in real-life footage has become a standard assignment in daily visual effects work. Especially in films where the average viewer would not expect such manipulations he tends to not be overly critical and accept small errors.

A very common task in visual effects is retouching actors faces and bodies, from simple removal of small spots and blemishes to extreme ageing or de-ageing, applying artwork to the skin or even enhancing facial expressions. If a shot features an actor this is usually the object of interest for the audience, making it much more challenging to hide any shortcomings of alterations.

When in pre-production of a film it usually becomes apparent that changes to an actors face will have to be made, usually the VFX supervisor will take the necessary steps to ensure that the work can be done in a successful and timely manner with the tools available.

The supervisor might ask the actor to keep his face mostly static or not to turn his head too much. This is often neither beneficial to the acting performance, nor can it be guaranteed to be maintained throughout a fast-paced day of shooting.

Humans are generally very familiar with their own kind and unsuccessful manipulations. If the tracking works for these cases, it will most likely work for other less critical cases as well.

Certain shapes of surfaces can also pose problems in tracking. If the surface is very round or deforming, common tracking methods fail and the next level of possible solutions means a significant step up in complexity and manual work.

Many known methods and tools are mimicking surface deformation by 2D warping and match-moving cross sections of the warping grid to underlying features of the surface.

A key technique for retouching a surface pattern however is to clone patches from nearby areas. Cloning only works if the relative positions of the patched areas to each other do not change while the surface is moving. To do this, the region must first be stabilized, clone-brushed and then match-moved again to its original motion.

This can be done with relatively flat surfaces using a planar-tracker such as Mocha[1] and the results are generally quite robust.

Non-planar surfaces can be tracked to a certain extent, but the tracking data can still only be applied to a flat plane. Accurate results can only be expected, if the target surface stays largely parallel to that plane and in the same depth, or considerable shifting will occur.

This is where the planar track would have to be broken down in smaller patches that need to be tracked and painted or stabilized separately. This method can quickly become very inflexible and cumbersome to set up.

Other methods would mean a significant step up in complexity. Motion capture or rotomation are very time-consuming and typically can only be done by specialists. This can be a burden for a smaller VFX house but surely be out of reach for a single VFX artist. Since visual effects assignments come with a significant price tag, it is vital to find a solution that is appropriate for the effects that need to be achieved.

AUTOPOSTs deformable surface tracking may solve this problem and keep the artist from using complex workarounds or leaving the application, while providing a unified, robust workflow for a variety of everyday tracking tasks.

1.2 Alpha Matting

Alpha matting refers to foreground extraction or splitting images or videos into individual layers with individual textures and alpha masks. It is a key process in post-production, mainly for compositing, retouching but also for color-grading.

Alpha matting is a complex problem, because it requires a lot of manual work to separate the different layers (rotoscoping), extract their individual alpha masks (matting or keying) and recover their original textures (inpainting or clean plate creation) from the composed image.

Generally, in a well-controlled environment such as a studio, backgrounds are in blue or green, and a good foreground extraction can be achieved by using chroma-keying techniques

However, very often the environment cannot be controlled and arbitrary backgrounds are found in exterior places or natural set where it's difficult to install big green or blue screens because of cost, weather conditions (wind, rain), camera movement, etc.

For this majority of shots, although tools exist, it requires a huge amount of manual work to extract shapes and mattes describing the individual layers. In addition to the complexity and the required time, the quality is often not sufficient due to artifacts generated by transparencies, motion blur and shape vibration.

AUTOPOSTs alpha matting may solve this by considering temporal consistency and a motion blur propagation scheme.

1.3 Combined Surface Tracking and Alpha Matting

There are a few use cases where both tracking and matting are needed and may benefit from each other. This includes extension sets behind the characters in action, the clean plate reconstruction with the elimination of occlusions, sequence retiming comprising layers at different speeds, and the propagation of rotoscoping curves and other manual clipping.

[1]http://www.imagineersystems.com/products/mocha-pro/

2. Use cases for surface tracking

2.1 Use case: Tracking a rigid object

Countless showcases exist on the internet where logos or typography are digitally changed on objects in a filmed scene. Usually the techniques are presented with largely flat surfaces such as billboards or street signs.

While the ultimate goal of AUTOPOST is to assist in tracking deformable surfaces, even the task of manipulating rigid objects can become a considerable problem if the object is curved and transforms in 3D space. While simple translation could still be described as a 2D motion plus scaling and recorded by a 2D tracking tool, rotation would be much harder to capture. The 2D tracker simply lacks the necessary solving mechanism.

If the objects rotation and curvature is relatively small, planar tracking might help to a certain degree, but while the actual tracking might work well enough, applying a pattern back to the curved surface will be a problem. The wider the pattern encompasses the object, the bigger the angle between surface and texture plane will be, showing visible shifts.

An alternative solution could be object tracking, which is fully 3D and therefore does not show those limitations. but since this object tracking requires a 3D model to start with, the artist would have to first build a 3D model of the object or acquire a 3D scan. This means considerably more setup time than the artist is likely to be granted for a quick logo removal.

2.1.1 Example: Changing a logo on a coffee mug

Removing or changing a logo on an object in filmed footage is usually an unforeseen and last minute assignment. A company may have requested to have their brand name removed from a particular object or a sponsor for a certain product placement changes his mind after actual shooting is already finished. If this happens, it can mean that in a short period of time, countless objects may have to be retouched and a quick and easy method will be needed.

An artist assigned with this task would typically start by evaluation the movement of the object. When filmed with a camera just rotating on a tripod, the whole image can be treated like a plane transforming in 2D space. Tracking 2 or 3 features in the footage will usually deliver enough 2D data to stabilize the object when used inverted on the image. This will produce a static canvas for painting out the logo and inserting a different one. When carefully removing the logo with a cloning tool, lighting changes might even be preserved, since the source for the cloned patches is still a frame sequence. When retouching is finished, the original tracking data will be used to transform the stabilized image back to its original movement.

Figure 1. Removal and changing of logos in "Zum weissen Rössl"

Successful patch cloning only works if the object offers enough surface area uncovered by the logo. If this is not the case, the surface may have to be retrieved from another object in the image or from a different source altogether (Figure 1: The two jugs in the image share interchangeable surface characteristics). Because the lighting might change differently on a different object in the scene, it often used as just a still frame and then lighting is recreated manually.

If the object is moved, using a planar tracker might be a bit more robust, with the downside that it is more difficult to manually refine the track. This might be necessary though, if for example specular reflections briefly confuse the tracker. Once the objects starts rotating visibly, unless it is distant to the camera, none of these methods will produce a satisfying result.

The task:

A pattern or logo on a moving and rotating coffee mug should be removed and be replaced by a new logo while surface and lighting characteristics should be preserved. Objects with a reasonable amount of shininess should still be usable.

Motion blur should match any pre-existing blur. To increase the complexity of the task, partial occlusions of the object will be introduced and lighting changes will be simulated.

2.2 Use case: Tracking a deforming surface

2.2.1 Example: Applying a tattoo to a body part

If a script calls for a tattoo or ornament of sorts on an actor's skin, usually it will be just painted on by a make-up artist. In some cases though, it is the directors wish to have the tattoo appear, transform or move on the skin.

In the title sequence of the US TV Series "Sons of Anarchy" for example, tattoos on body parts of the main characters transform into the actors written name. In the poetic short documentary "Mr.X" about a British tattoo artist, ink ornaments of his own designs slowly start to "grow" on his body while he talks about his art. Figure 2 shows the tattoo effect applied to Mila Kunis back in "Black Swan". The actress was filmed with tracking markers and then a digital tattoo that transforms from a flower into wings, was added.

Figure 2. Digital tattoo on actress Mila Kunis in "Black Swan"

Skin texture and colour can range from almost featureless to freckled or wrinkled, dark or bright, dry or oily, all of which can pose a considerable challenge for tracking. While a well-lit close-up might work well without the additional use of markers, other situations will demand more preparation.

Once the skin area is properly tracked, it does not actually make a difference if the artwork is transforming or static. A static tattoo will probably even make it easier to spot small tracking errors. This method can also work well to apply scars, bruises and other skin texture.

A common approach to tracking deforming skin is using a planar tracker. The more recent algorithms provide fairly robust tracking and using it is rather easy. The artist draws a spline shape around an area on the surface and the tracker will usually work from there with minor user input. Unfortunately, there are also very few options to improve the tracking in case it is unsuccessful. No additional user tracking data can be added to refine the track.

Data output is also rather limited. Even though many features in the outlined area may get tracked, the tracker will only provide a 2D transformation in form of a corner pin (a stretchable plane with 4 independently moving corners) or a matrix transformation. Corner pinning or shearing of the planar area will allow to simulate minor uniform skin stretching. To track complex non-uniform movements the area must be broken down into several single planar tracks. Some deformation such as bulging or folding are very difficult to capture.

Besides using the corner pin data to match move an element to the skin, it can also be copied to a grid or spline based warp tool. While this can help to connect multiple planar tracks into one unified warp, there is currently no functionality in commonly used tools (Nuke[2] or Mocha[3]) to automate this process. This method can also be applied with just using animation data from many simple 2D trackers to drive a 2D grid warp.

The task:

A tattoo should be added to a stretching and bulging part of skin. It must first be warped in place to follow the curvature of the body part and in the frame sequence stick believably to any skin deformation. The tracking should work without the use of additional tracking markers, although tests with the aid of small dot-like markers will also be performed.

Varying lighting conditions and shadows cast on the surface, as well as partial occlusions will also be tested. Realistically, at some point a track can no longer be performed. The skin movement should be tested ranging from minor to extreme and the track should remain intact even if parts of the skin bulge away from the camera in steep angles. Tests with and without additional tracking markers will be performed. Some skin may show no detectable detail at all and might not be trackable without the application of artificial tracking features

The original skin detail should remain largely intact and lighting should look natural. Motion blur will be added and must be consistent with original.

2.2.2 Example: Digital makeup

Digital make-up is an ever-growing field in today's visual effects. For many manipulations other than just adding make-up, a layer of latex has to be applied to the skin as a canvas for further modifications. This usually adds peculiar looking volume to the face and makes it difficult for the actor to give a subtle performance.

Digital de-ageing (or ageing), has become a popular alternative and the results can be very successful. Recent impressive examples are the transformation of actor Patrick Stewart and Ian

[2]http://www.thefoundry.co.uk/products/nuke/

[3]http://www.imagineersystems.com/products/mocha-pro/

McKellen into their 25 years younger selfs in the movie "X-Men: The Last Stand" or the dramatic digital ageing of Agent Peggy Carter in the first "Captain America" movie shown in Figure 3.

Figure 3. Digital aging of Agent Peggy Carter in "Captain America"

Digital make-up or makeover can also be beneficial to enhance practical make-up effects, as seen in the TV series "Falling Skies". The alien character "Cochise", played by an actor with a full-head mask receives significant digital enhancements of his facial expression, allowing for subtleties not possible with just a animatronic rubber mask. Because the viewer is naturally so familiar with the subtle nuances in facial detail, great care must be taken to retain skin characteristics even when doing dramatic changes to the larger structures of the face tissue.

Digitally removing smaller wrinkles and blemishes is frequently requested even in small scale film productions or advertising. Complicated makeovers are usually out of reach due to time constraints and the simplest of all methods is used: manually masking out and blurring areas of the face. This unfortunately makes the skin look unnaturally smooth and artificial. For better results a technique called frequency separation can be employed. Using a combination of blurs and high-pass filters, a specific detail frequency can be targeted and retouched, leaving smaller or larger details intact.

For larger corrections, planar tracking can be used to stabilize and clone-paint portions of the face. Unfortunately, the connective tissue in older skin is weakening and therefore the skin movements are much less uniform. This requires tracking more and smaller patches to capture the deformations, especially around the mouth and cheeks. Additional tracks and masks may be needed to reshape the chin and jaw area of the face, where skin tissue starts to sag in older age.

In extreme cases of ageing or de-ageing, when paint and blur methods do not give convincing results, entire portions of a different persons skin might be match-moved to the actors face (Figure 3) The skin of an older woman was re-projected on actress Halyay Atwells face in "Captain America". On top of the 6 visible tracking markers, 75 additional points where individually tracked and then applied to a corresponding mesh, covering the entire face.

The task:

A talking and moving actor's face should be retouched, primarily for the purpose of de-ageing. Wrinkles, spots or blemishes should be removed and parts of the face be reshaped to counteract sagging and puffiness. The skin should show stretching and bulging but keep a natural texture and coloration. Lighting changes should still look natural.

To increase the complexity, the actor should be allowed to turn his head slightly or touch his face while talking. Tests with and without tracking markers will be performed.

2.3 Use case: Sticking 3D objects to a deforming surface

The use cases so far concentrated on applying 2D manipulations to tracked surfaces. Often it is also desirable to add depth and parallax to the augmented elements. Objects should appear to "stick out" of a surface or it should look dented or cut open, revealing underlying structures. This can greatly enhance the dramatic look of CG effects on a real-live organic surface

A 2D solution would give away this illusion immediately, once the surface starts facing away from the camera. These effects are beyond the scope of 2D warping. As a basis for building effects like these is usually a 3D mesh that tightly matches the movements of an actor or body part.

While this task is more complex it is also more likely that some planning was done prior to filming the shot. It might be more of a story element and less of a last-minute repair effect.

There are three common methods to augment a 3D mesh over a real actor's skin: object tracking, motion Capturing and rotomation.

Object tracking works reliably only on relatively rigid objects which greatly limits its use on skinned body parts. It might work on an actor's forehead for example, where deformation is negligible, or for a whole head if the deforming parts will be covered by a CG element later.

Motion capturing demands precise preparation before and during actual live filming (tracking markers, multiple cameras or motion capture suits), often combined with a high resolution 3D-bodyscan of the actor as a base model. Motion capture data needs to be cleaned and refined in dedicated software. It is used mostly for full-body tracking.

The cost of these technologies and production effort can naturally only be justified by an appropriate amount of use in the entire film and are out of reach for movies with smaller budgets or for a single effect shot

A recent example would be the movie "Green Lantern" where the body of the main character was covered with a CG hero-suit for all the scenes in the movie.

In rotomation a model is manually posed and animated to match the actor's movements. While this method is often the only option if an automated tracking is not possible, it is extremely time-costly and requires a considerable amount of setup time, before animation can even start.

Therefore an automated tracking of body parts with reduced setup time to produce usable 3D data would be a tremendous advantage for smaller productions.

2.3.1 Example: Adding objects to a characters skin

In our use case we want to concentrate on extending digital makeup effects with additional 3D elements. While digital makeup can produce great results for changing skin texture when the camera looks straight at it, more dramatic effects can be achieved if bigger structures can create an extra layer that enhances the silhouette of the character. An interesting example would be the shape-shifting effect of the character "Mystique" in the X-Men movies or the small feathery bumps on Natalie Portman's skin, prior to her transition in the movie "Black Swan" as shown in Figure 4. The actors wear practical make-up most of the time, but for the actual transition effect or if the make-up needs to be "alive" digital makeup is chosen as a more flexible solution.

Figure 4. 3D bumps on Nathalie Portman's skin in "Black Swan"

To place 3D geometry on a characters skin it is necessary to extrapolate 3D coordinates from the 2D footage in form of a point cloud or mesh. Besides moving correctly in 3D space, this base mesh will provide surface normals, so an attached geometry can retrieve position and orientation data. The mesh also acts as a projection surface to catch shadows cast by the geometry or to occlude it when moving between the objects and the camera.

To generate the 3D mesh animation, a 3D model has to be built and fit perfectly to the body part that needs to be tracked. For rigid parts, a normal object tracker will output 3D transformation data that can be applied to the whole mesh. Some tools like PFTrack[4] offer a dedicated "geometry tracking" mode, where the mesh itself aids in tracking.

For complex movements with many non-uniformly moving parts or deforming surfaces, the other commonly used method would be rotomation. A base model is setup similar to object tracking, but than keyframed manually, literally reanimating the character. This technique is often chosen for its flexibility despite being the most time-consuming one.

The tracking must be robust either way, but if the skin is later densely covered with 3D geometry, usually one would also replace the underlying skin with a patch just to make sure the area of interest moves coherently. The seam to the underlying real skin can often be hidden on the edge to the parts covered by clothing or by going off-screen.

It is important that the skin movement is not only exact, but also smooth, as objects pointing away from the surface will indicate incorrect or nervous motion more pronounced then flat textures.

The task:

A deforming part of the actor's body should be tracked and small chunks of ice or debris should be attached to the skin. They should move convincingly and cast shadows on the skin. Ideally, a deforming 3D mesh could be exported to a 3D application. This mesh should provide proper texture

[4]http://www.thepixelfarm.co.uk/products/PFTrack

coordinates and have the underlying skin texture mapped, so a whole skin patch can be replaced if necessary. To increase the complexity of the task, the body part should be at some time partly occluded, leaving the frame or coming in and out of a shadow area. 3D objects with various shapes and lengths should be attached to the skin surface. Longer objects should still move smooth and consistently.

3. Use cases for alpha matting

Alpha matting refers to the problem of accurate extraction of foreground objects in images and videos, and is one of the key techniques in many post-production applications, mostly for compositing, but also for localized editing and image and video cut and paste.

Computing a matte is an ill-posed problem since at any pixel we have more unknowns (the foreground and background color plus the alpha) than the only data available, the observed pixel color. Therefore, further assumptions are needed to make the problem solvable. This is commonly addressed by making assumptions on the foreground and background image and/or the matte.

In the use cases, we will be focusing on specific situations and difficulties that result from there.

3.1 Use case: Matting of head with hair

Matting a head with hair is one of the most typical situations. We usually try to avoid this situation by keeping the foreground and the background clean because extracting the head with the hair can be a pretty complex and time consuming task.

The main difficulty is to manage the size and the transparency of the hair. Sometime, we need to limit the hair by a fraction of a pixel to be sharp enough and avoid artefacts. Moreover, the movement of the hair must be fluid and natural. If the matting is done frame by frame, flickering may appear which looks very unnatural. Furthermore, the non-rigid motion must be considered when rotoscoping.

To deal with this kind of shoots (head with hair), several techniques (luma and chroma keying, manual rotoscoping, etc.) are usually combined knowing that none of them is enough by itself. The AUTOPOST matting algorithm may combine different techniques to achieve a naturally moving matte.

In the film "Home", many shots include moving vehicles on a highway. For reasons of security, shot with the actors were separated from those with cars and trucks. As the choreography of vehicles should be defined after the shooting; cars have been inserted between the characters and the background. The difficulty was the matting of the actors head and hair (Figure 5) but also the extraction of the moving vehicles.

Figure 5. Matting Kacey Mottet-Klein hair in "Home"

The task:

Important work of clipping hair had to be done, supplemented with various chroma keying techniques on the dive mask and clothing. In that particular case, additional complexity came from the similar appearance of hair and wheat field in the rear.

3.2 Use case: Matting of objects with motion blur

As well as for a moving head with hair, there are many difficulties to create a mask with moving object because of the motion blur. Motion blur is the apparent transparencies along the boundaries of rapidly moving objects in a still image or a sequence of images. It appears when the image being recorded changes during the recording of a single frame, either due to rapid movement or long exposure. The main issue with the motion is the transparency that must be managed in relation with the speed of the object. Moreover the borders are hardly limited, which makes the rotoscoping even more difficult to do.

In Figure 6 the boy is walking which causes a light arms and legs have a light motion blur. The vehicles were fast moving with a significant perspective which introduced a highly variable motion blur effect.

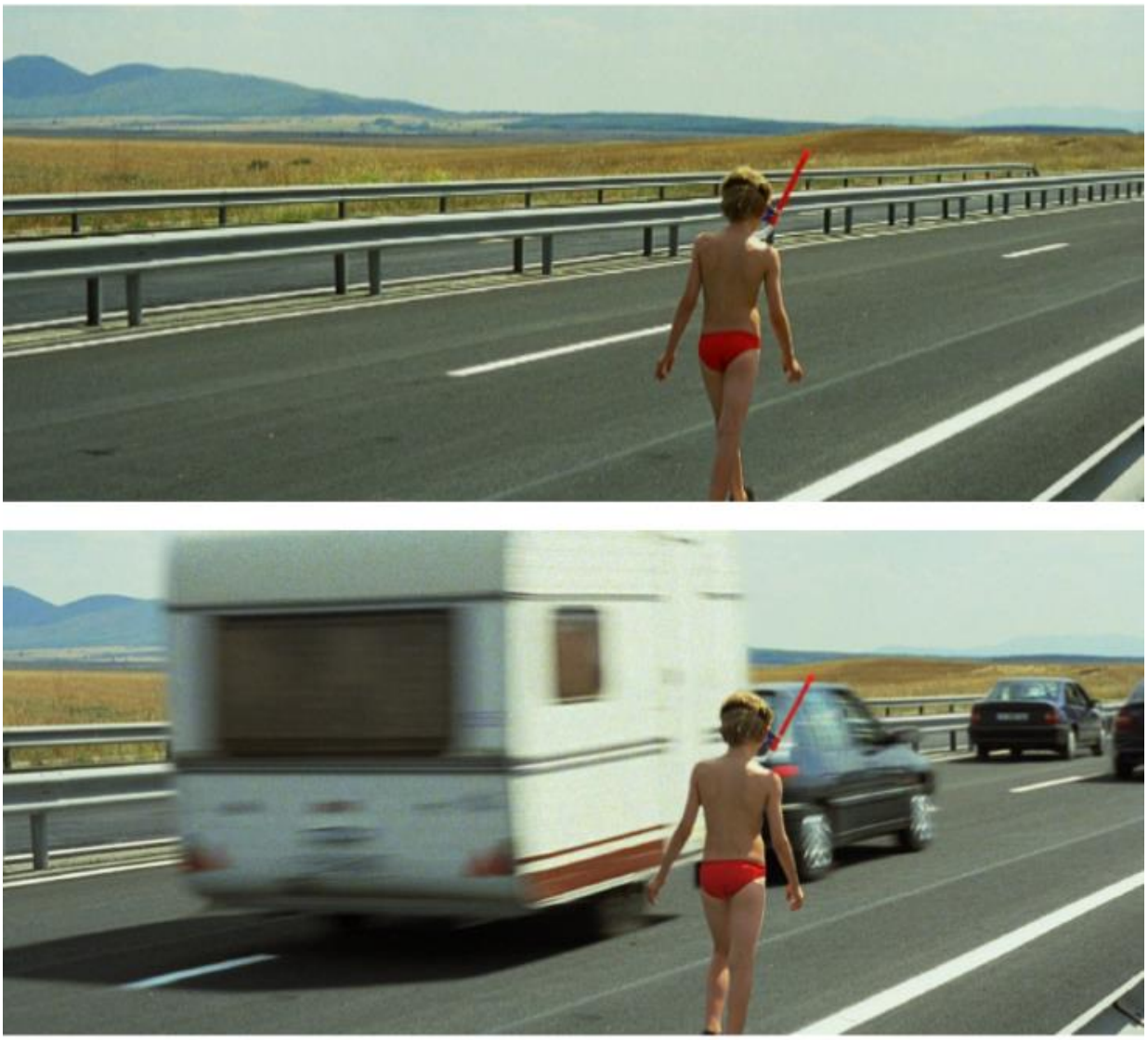

Figure 6. Matting Kacey Mottet-Klein hair in "Home"

The additional difficulty was that the two passes (with and without cars) were filmed with a moving camera. The two takes were not exactly with the same moving camera. The boy and the background have been kept from the first pass. The cars have been recorded with an angle a bit wider because the sharpness was less important than on the pass with the boy. The synchronization has been done on the road of the two passes. Finally, masks for the boy and every car were needed and all of them had motion blur.

The task:

The work involved trimming the portion of the boy in the vehicles passing zone. A combination of chroma and luma keying as well as rotoscoping was used because trimaps were not available at the time of the film post-production. The many moving vehicles have also been clipped, with the added difficulty of variable motion blur, window transparencies, drop shadows and a continously moving camera.

3.3 Use case: Moving FG and static BG

In the case of filming actors on front of a green screen, the rear sets are fixed in order to avoid camera motion control. Similarly, for natural backgrounds taken due to weather conditions or outdoor settings, a fixed or light panoramic framework might be needed. The interesting advantage is to extract the difference between the clean background and the filmed image, as the objects in the foreground such as a character or vehicle are moving.

Figure 7. “White night”

The objective in Figure 7was to insert the mountains behind the moving helicopter. These plans were filmed in Belgium there are no mountains in this country. In many films, this technique for background reconstruction is used for reasons of cost but requires the use of alpha matting.

The task:

The work involved trimming the portion of the helicopter in the area provided for the insertion of the mountain. The advantage of a moving helicopter and the static background was exploited for extracting the background without the helicopter (clean plate). The difference with the original image subjected to a thresholding, allowed to extract the helicopter mask despite the presence of clouds in the sky. The transparency of the cockpit windows and the blade movement was handled properly by a punctual manual intervention.

3.4 Use case: Enhancing or replacing the background

In post-production, there is often a demand for background enhancements. This may include the removal of unwanted objects (GSM antenna, power cables, tags, etc.), but also changing the background textures by adding snow, dirt or material, as well as the addition of mists and fog. It is obvious that for this kind of task there will be almost always some foreground objects which must be isolated to place these elements.

3.4.1 Example: Adding snow to the scene

In the movie "Oscar and the Lady in Pink" many plans included snow as shown in Figure 8. For all ground areas in direct interaction with the character (e.g. shoes), fake snow was used during the production but it was impossible to cover the rest of the scene (e.g. the village) with snow. The camera was moving slowly in the vertical direction which involved a clipping all the trees and houses.

Figure 8. Michèle Laroque in "Oscar and the Lady in Pink"

3.4.2 Example: Replacing the background and adding fog

In postproduction, all kinds of techniques to modify, improve or add a dramatic side to the shots are requested by the director. For example, mists and fog are often interacting with the landscape and therefore require a separation of the scene into different layers to give the desired depth.

In the film "Asylum Blackout", all the action takes place in an isolated area of the United States; or the entire shoot was conducted in Belgium in a scientific park; only a portion of the buildings corresponded to the expectations of the director. So any changes that could increase the feeling of a prison in a remote location in the rain was welcome.

Figure 9. "Asylum Blackout"

The task:

Almost the entire background has been replaced. Therefore, the moving truck was rotoscoped during the whole shot. Because we had to integrate rain between the different positions of the truck, other elements had to be rotoscoped as well.

3.5 Use case: Select objects for color grading and finishing

Modifying the color or brightness of an object or surface usually referred to as color grading is a common postproduction task. That can be used in situations where there is a different light between different parts of a scene (landscape through a windows, etc.) or when a change of focus or grain (blur and texture) is required.

Figure 10. Isabelle Hupert in "Home"

For the story the asphalt of the highway had to be fresh, so much darker than the original. The difficulty was to separate the street from characters to change its color. The shot duration was relatively long with players jumping at every step.

The task:

The work involved trimming the different players on the road, using a combination of chroma keying techniques and rotoscoping. The shadows were to be treated as well. The arm in the foreground was also pretty difficult due to the depth of field blur. Due to the static camera background differencing between a clean plate and the image has been used as well.

4. Use cases for combined tracking and matting

There are often shots that combine the various difficulties associated with the movement of objects as well as that of the camera. When an object that needs to be modified is deformed by its movement or that of the camera and at the same time it is hidden by another moving object, then a combination surface tracking and alpha matting is required.

Also, in the case of selective retiming, where the goal is to change the speed of a shot both matting and tracking are required. This process requires the separation of different areas of differentiated movement and reconstruct the hidden areas by recovery from other frames.

4.1 Use case: Track background and matte foreground for set extension or replacement

The action of the film, "Distant Neighborhood", happens mainly in the fifties and therefore at this time the white dotted lines on the road did not exist. The only solution was to delete them during postproduction. The difficulty was that everything moves including the camera and the individual vehicles. The road should be treated as a 3D object with texture in permanent change (light, grain) and a motorcycle zigzagging between lanes.

Figure 11. Removing road markings in "Distant Neighborhood"

The task:

First, the work was to perform a complete tracking of the road and the surroundings in order to deduce the camera movement. Tracking points determined in 3D space, have served as a basis for the 3D modeling of the road followed by a removal of the white markings in the unfolded and animated texture. Finally, the 3 moving objects (motorcycle, car, van) were clipped in order to reduce the rework of the road area without erasing the objects. In the end, adjustments in the shadows and the light changes were made.

4.2 Use case: Retiming of shots with diverse motion

In many movies, the editor often performs speed changes to accentuate certain shots. When different portions of the image have different motions, interpolation of intermediate images may

introduce artifacts. A combined use of tracking and matting can be very helpful to deal with each layer separately and to automatically fill uncovered areas.

For example, in the film "Vitabrevis", a kind of aesthetic tale where the director attached utmost importance to the motion of the characters, mainly birds and flying insects. Therefore, the speed of most shots were modified for added poetry, while retaining maximum fluidity. In general, slow motion algorithms introduce very annoying judder and artifacts on the edges of moving objects. The additional challenge also came from the motion of the camera on the boat preventing sufficient stabilization.

Figure 12. “Vitabrevis"

Given the complexity of the background and detail of the bird, the only possibility for a fluid slow motion, was to separate the bird from rear branches and to reconstruct the background without the heron by multi-point tracking. The retiming was therefore carried out on both layers separately and both layers were composed after manual modifications on the feathers of the bird. The combination of more sophisticated alpha matting and surface tracking methods would certainly reduce postproduction time for this long clip.

5. Conclusion

The use cases chosen for this deliverable show some of the most challenging problems in tracking and matting for visual effects. Solution that prove their usefulness in these cases will no doubt benefit a vast number of less complex but frequent tasks.

Naturally, when use cases like these are documented in making-ofs and breakdowns by the VFX industry, the sole reason is that these problems are ever so hard to tackle. Even seasoned visual effects professionals are sometimes puzzled by the amount of effort that made them possible.

While these high-profile visual effects receive admiration for their obvious complexity, many of our use cases represent the daily business of countless rotoscoping and matchmoving artists. They are what the visual effects industry calls "the unsung heroes", because their work, if done perfectly, goes completely unnoticed by the general audience. A tool that can significantly reduce their workload will without doubt be very welcomed by a VFX community that struggles everyday too meet the high expectations created by it's own achievements while suffering from sinking budgets and fierce competition.

Almost all other areas of software development addressing the needs of visual effects work are subject to constant innovation. Motion capturing, 3D scanning, rendering or fluid simulation tools have drastically advanced in the last years. Compositing is one of the few fields where innovative solutions are rather hard to find. Many of the techniques are simply digital versions of their age-old analogue counter-parts, more comfortable to use but still largely manual in nature.

AUTOPOST aims to provide a set of advanced matting and tracking tools that perform tasks in which a skilled artist knows the exact steps to solve them, but lacks tools in his compositing software that understand and automate the process in order to reduce the required efforts and improve the overall quality.

No single tool or method can provide a solution for all the possible problems that can occur in real footage, shot on a tight schedule, as is the rule in film production rather than the exception. There will always be visual effects tasks that can be tackled only with brute force and cumbersome manual work. This, fortunately, is the exception and if the time artists spend on the majority of visual effects work can be minimized by the AUTOPOST tools, the whole production will benefit from the time saved.

Based on the definition of the use cases equivalent life footage will be created in a controlled environment in order to test and evaluate the production-worthiness of the proposed AUTOPOST Plugin Suite. To take into account the inevitable variety of individual problems in real-world production footage, examples with increasing complexity will be produced. This will allow for in-depth stress-testing of the AUTOPOST tools and help to systematically measure improvements.