# Raising Awareness for Endangered Species using Augmented Reality

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## 1. Introduction

Without the support of the local population, the protection of endangered species is difficult to implement. The effectiveness of protection measures often relies on people to adapt their habits and take biodiversity into account in their daily actions [1]. The effort to achieve this change of mindset depends on two main factors. Firstly, on the degree to which habits are affected, and secondly, on the species to be protected. Species that are perceived as less aesthetically pleasing or useful are often less interesting [2][3]. The same applies to shy or very small species, which are often hardly noticed by society. Thus, their extinction may be conceived as less severe or not perceived at all [3][4].

Communication strategies determine the approaches that can be used to establish and expand contact with the target group in order to achieve a long-term adaptation of behavior [1]. The Convention on Biological Diversity (CBD)[1] lists various communication approaches: Billboards, posters and fact sheets serve as visually appealing sources of information. Coloring books, photo calendars and documentaries increase familiarity with unknown species, while mascots, board games or puppet shows allow to playfully explore them [1][5]. These strategies have proven to be successful. However, an increased need for sustainable approaches and contemporary media suggests an adaptation of strategies. Reduced use of print products, less development of natural areas (such as information boards), as well as immersive offers, that convey content in a varied and inclusive way, are coming to the fore. The use of Augmented Reality (AR) might offer a promising solution to these issues.

AR makes it possible to extend reality by adding virtual content, which is then displayed via mobile devices or data glasses [6][7]. Although AR in principle appeals to all senses, today's focus is mostly on the visual representation, which occurs in the form of texts, images, videos, 2D and 3D objects and animations [8]. Computer-generated additional information has already been used for several years, for example in live broadcasts of sports events, in tourism [9][10], for educational purposes [8][11], in museums [12], at archaeological sites [13] or in games [10][14]. So far, the possibilities of AR in making the invisible visible and in establishing a first contact with species have rarely been considered as a communication strategy. As in many industries, AR has been used in environmental communication primarily for marketing

[1] https://www.cbd.int/convention/

purposes, for example by WWF-Armenia[2]. The conservation organization presents a virtual leopard via an AR App for the Environmental Campaign "Take a photo with the Leopard". The goal of the campaign is to draw attention to this highly endangered animal [15]. Other examples are the AR installations by National Geographic in which shopping mall visitors can observe and interact with wild animals such as elephants, polar bears and dolphins via a large AR screen [16].

In cooperation with the Wildland-Stiftung Bayern, we develop fields of applications for AR in environmental communication and education for the nature reserve "Thalhamer Moos". Special attention is given to the reduction of nature development and the creation of immersive, entertaining experiences for all ages. This paper documents in particular the steps for the development of virtual animals, which originate from the low-moor and are endangered.

## 2. Use Case "Thalhamer Moos"

The low-moor "Thalhamer Moos" is located in the Isen Valley west of Mühldorf am Inn in Bavaria, Germany and has been classified as a European protected area since 2004 because of its important role as a habitat for rare animal and plant species. In order to preserve this native ecosystem, some areas are purchased to upgrade them for nature conservation purposes. These are managed extensively, creating new habitats for rare insects, amphibians and bird species. A nature trail is planned with the goal of informing the local population interested in the "Thalhamer Moos" about its special local flora and fauna. It will also focus on the importance of moors for species and climate protection and thus aims to achieve an acceptance of the restrictions associated with the protection.

In this context, the use of a mobile augmented reality app is to be tested. By using the app, users can benefit from a further source of information in addition to the standard information boards which will be set up at chosen locations. The app should be accessible during and after the visit. Additional multimedia elements such as animal voices and short video sequences ensure a multi-faceted environmental education and motivate the user to focus all her senses on nature.

In order to be able to test the effectiveness of AR applications (abbreviated AR Apps) as a communication strategy, we will present and compare different techniques of modeling, texturing and animation for the implementation of 3D models of different endangered bird species, in particular meadow breeders.

To enable the use of AR as an approach to communicate environmental issues which can also be applied by low-budget conservation initiatives, the results are classified according to time, cost, effectiveness and feasibility. We also pay attention to performance and use of storage to enable the use of AR for older and low-end mobile devices and low-bandwidth connections.

## 3. Developing the Appearance of Virtual Birds

In animated films, virtual animals can now be represented nearly realistically thanks to improvements in rendering and post-processing techniques, which are not yet widely supported by video games and AR [17].

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[2] https://wwf.panda.org/wwf_offices/armenia/

Because of these limitations, many game developers use characters in cartoon style, since the users regard anomalies in their look and movement as less negative [18]. The phenomenon, that the acceptance of a human-like machine decreases enormously as soon as it shows behavior that is atypical for a human being, was first described as the "Uncanny Valley" in 1970 by roboticist Masahiro Mori [19]. This observation also applies to virtual animals: Realistic cat models with a slightly abnormal appearance or atypical facial expressions and gestures are perceived as sick and repulsive [17].

Because the intensity and duration of the examination of a virtual character does not depend on its degree of realism, the decision for or against a particularly realistic appearance of the virtual figures can be made by considering their intended purpose [20][21].

Our virtual birds are representatives of the real animal species. However, for this connection to be understood, they have to resemble their biological counterparts strongly enough in appearance and behavior. This is why we decided against utilizing an abstract, comic-style version. In order not to exceed the file size of the planned application, we pay special attention to minimizing the amount of data. This includes investigating the use of textures in order to achieve a realistic and detailed appearance despite a reduced 3D mesh.

## 3.1 Lapwing Version 1

Using Autodesk's 3ds Max[3], the first 3D model of a pigeon-sized lapwing was built. It consists of one mesh, representing the bird's torso, head and legs (Fig. 1). The texture (diffuse map) was assembled from various photos and revised in Photoshop CC (Adobe)[4]. We used this model to perform the first AR tests with spectators. Despite this relatively simple realization, the reactions to the virtual bird were very positive, which may, of course, at least in parts be attributed to the novelty of this technology.  We were particularly surprised by the effect of a short head animation, which contributes to a much more vivid appearance of the virtual lapwing. The animation was also created in 3ds Max using the Character Animation Toolkit (CAT). This plugin supports rigging as well as animation and allows already created animations to be transferred to other 3D models.

[3] https://www.autodesk.de/products/3ds-max/overview

[4] https://www.adobe.com/de/products/photoshop.html

**Fig. 1.** 3D model of the first version of the Lapwing and its diffuse map.

### 3.2 Lapwing Version 2

Because of its unique way of flying, the lapwing is also called "Acrobat of the skies" [22]. In order to demonstrate this distinctive feature, we refined the 3D model of the lapwing with unfolded wings and individual feathers (Fig. 2). This pose, known in character animation as the T-pose, is particularly suitable for rigging and animating. However, it quickly became clear that animating each individual feather is a very difficult and time-consuming task that could not be done for every planned bird model of the meadow breeders we plan to include. We decided not to design the AR scene like a circus show, where the peculiarities of each animal are presented, but to give an insight into a natural situation that is as undisturbed as possible. Therefore, we decided against elaborate flight animations and focused more on achieving a realistic overall appearance of the lapwing.

**Fig. 2.** 3D model of the second version of the Lapwing and the diffuse map of its body.

### 3.3 Lapwing Version 3

In order to achieve this naturalistic look, we prepared a third version of the lapwing with its wings folded (Fig. 3). This time the effect of a thick plumage should not be achieved by a multitude of individually modeled feathers, but by the sophisticated combination of diffuse, normal and opacity maps. Since this was difficult to realize with the previous means, we deployed the 3D painting software Substance Painter (Adobe)[5]. With its help, the textures created with Adobe Photoshop were refined and normal maps were added. With little effort, we were able to add a realistic touch to the previously smooth surface of the 3D mesh. This contributed to a much more vivid appearance of the entire model. Opacity Maps give the individual feathers a filigree appearance while keeping the number of needed polygons low. The animations, which were initially quite rudimentary (breathing, head movement, leg lifting) were so effective

[5] https://www.substance3d.com/

that we could abstain from creating more elaborate animations. Fig. 4 shows several renderings of the Lapwing animation.

**Fig. 3.** 3D model of the third version of the Lapwing and the diffuse map of its body.

**Fig. 4.** Renderings of the Lapwing animation.

## 4. Alternatives to 3D Modeling

We created and compared different 3D models of a lapwing in order to define an appearance style which best represents the species in AR. The modeling of the meshes, the texturing and the animation were thereby taken into account.

### 4.1 3D Sculpting

When modeling generic shapes, sculpt based programs such as ZBrush[6] (Pixologic) are preferred over polygonal modeling programs such as 3ds Max and Maya (Autodesk). To compare the advantages of 3D modeling and 3D sculpting programs, we created a 3D model of a snipe with ZBrush (Fig. 5).

[6] http://pixologic.com/features/

**Fig. 5.** Rendering of the Snipe.

The knowledge gained from the production of the lapwing models led us to only visually indicate the wings of the 3D model of the snipe with the help of normal and opacity maps (Fig. 6). The division into three meshes (leg, leg, torso) also proved to be favorable for the following animation.

The use of ZBrush clearly accelerated the production of the 3D model of the snipe, since the texturing can be carried out directly in the program. This means that we can omit the complex change between the programs (3ds Max, Photoshop and Substance Painter) and the generation of UV maps. The animation of the snipe was again created in 3ds Max with the help of CAT.

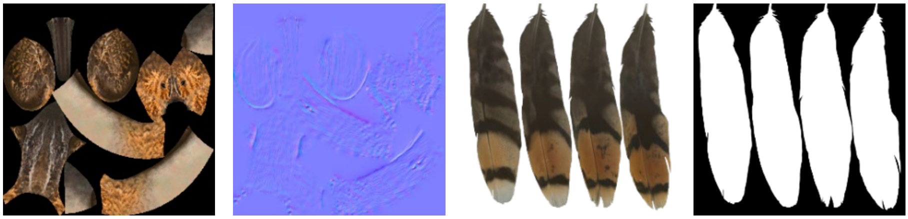

**Fig. 6.** Diffuse and normal map for the 3D model of the Snipe. Diffuse and opacity map for its feathers.

## 4.2 3D Reconstruction

The creation of the 3D models requires a lot of previous experience and is very time-consuming, even with the help of sculpting programs. Furthermore, the acquisition costs of individual programs are sometimes very high, which can be difficult to finance by environmental initiatives with low budgets. In order to test an approach of creating 3D models that requires little training, we decided to use photogrammetry.

In photogrammetry, a real object is photographed from as many angles as possible. With the aid of special software, a point cloud and a 3D model are then generated. The quality of the model depends on the

number and quality of the photos as well as the computing power of the computer. In this way, complicated 3D models can be created in a short time, without prior knowledge of 3D modeling.
In order to test the possibilities of photogrammetry, the Wildland-Stiftung Bayern lent us a stuffed grouse owl, which was photographed with a reflex camera (Canon EOS 60D, aperture: F/4, exposure time: 1/30sec, ISO:1600, focal length: 17mm, no flash).

From a selection of 93 photos, we calculated one model of the owl with the photogrammetry program Meshroom[7] (AliceVision) and another with the photogrammetry program ReCap Photo[8] (Autodesk). Both programs took about two hours to generate the topology and texture. ReCap offered significantly better results (Fig. 7). This becomes particularly clear with regard to the number of polygons of the results, which in the ReCap model are only one eighth of the number of the Meshroom model. In addition, the textures of ReCap are distinctly superior to those of the open source program Meshroom.

Since photogrammetry outputs the 3D models with a very high number of polygons, subsequent post-processing is necessary. We deleted fragments of the environment, corrected errors in the generated mesh and reduced the number of polygons. The amount of postprocessing depends not only on the program but also on the photos used, the complexity of the object and the intended use. The 3D models, which are calculated using photogrammetry software, consist of a single mesh, which limits the possibilities of subsequent animation. In order to bring the model of the grouse owl to life, we therefore decided to add discreet breath animation and a simple head movement.

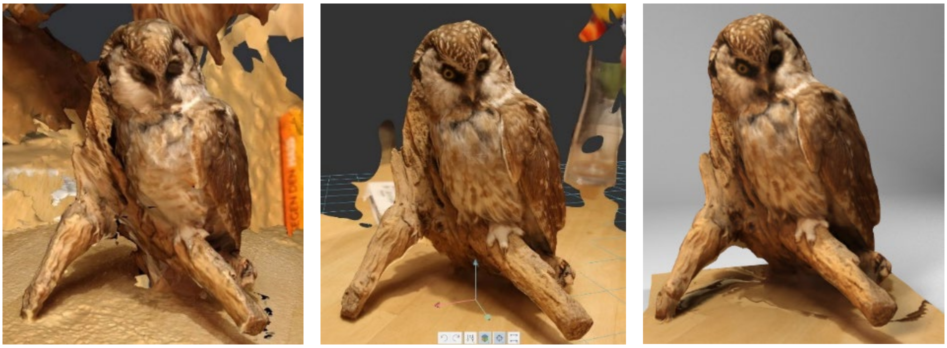

**Fig. 7.** Photogrammetry outputs of the grouse owl from Meshroom (left), ReCap Photo (middle) and the optimized mesh (right).

## 5. Marker-based AR App

To test the effect of our 3D models in Augmented Reality, we developed a simple marker-based AR project in Unity 3D[9] (Fig. 8). The promising possibilities of Web AR cannot be considered in this case. As in many

[7] https://alicevision.org/
[8] https://www.autodesk.de/products/recap/overview
[9] https://unity3d.com/de/unity

other rural areas, there is no sufficient internet connection in the “Thalhamer Moos”. Regarding vandalism and abrasion, marker-based tracking does not appear to be the ideal tracking method for public spaces. However, the permanently integrated markers simplify the use of AR View. Therefore, inexperienced users easily understand where to find virtual content.


**Fig. 8.** The lapwing in AR View.

For tracking we used the software development kit Vuforia. A large and active online community as well as many informative tutorials facilitated the introductory phase. Especially helpful is the possibility to check model modifications via a webcam directly in the Unity Editor. Marker-based tracking via Vuforia is very stable if the selected images are recognized sufficiently well. To test the virtual animals, we have created image targets (Fig. 9) that provide enough detail to be recognized by the Vuforia Engine.


**Fig. 9.** Image Targets to test the AR Content.

Besides Vuforia, we also tested AR Core for our purposes. We were particularly pleased that the lighting of the virtual models was adapted to the real lighting conditions. Especially when used in nature with constantly changing lighting conditions, this light estimation contributes strongly to our effort to integrate the models into the real environment as well as possible.

Advances in target recognition, in tracking performance and the ease of testing virtual content with game engines make it possible to compellingly integrate the virtual animal into reality. This turns AR into a very promising tool for environmental communication.

## 6. Conclusion

While the Wildland-Stiftung carried out the content planning of the nature trail, we dealt with the possibilities offered by a mobile AR App to communicate the goals of the path in an easy and more entertaining way. The goal of all efforts is to:

- Provide information about local animal species
- Raise awareness of local animal species
- Motivate people to change their behavior in terms of species protection

We recognized the potential to embed rare meadow breeders with AR in their natural environment as a promising communication strategy. The virtual birds represent animal species which are very difficult to observe due to their rarity or shyness. The app will allow the user to watch the birds close up, receive information about them and get to know them better. AR will not serve as a medium to introduce all peculiarities of the animals, but as a possibility to experience them in an undisturbed and natural situation. In order to be able to begin with the implementation of the virtual animals after the planning of the path, we developed an appearance guide for the 3D models that supported these 3 ambitions:

- Realistic enough to be associated with the animal species
- Simplified enough to keep the AR App small
- Accurate enough to circumvent the uncanny valley

Ambition 1: Realistic: In order for viewers to perceive the virtual birds as representatives of an existing animal species, it is necessary to combine an easy to animate 3D model with a high-quality texture. The well-directed use of normal maps give the model a haptic appearance and animations bring it to life. It should be mentioned that animations created for the use in AR have to be more expressive than usual animations, because they are perceived less clearly via the mobile device.

Ambition 2: Simplified: Keeping the polygon count of each 3D model as small as possible contradicts the ambition above. However, for the success of the AR App, a reduction of the storage space is crucial: the willingness to download or favorably rate an app rapidly decreases with its file size [23]. In order to ensure that most of the visitors will have access to the virtual animals, the file size must not exceed the computing capacity and performance of low-end devices. For this reason, the 3D model needs to be simplified and should be further reduced by using normal and opacity maps. We aim to include 6-8 species, while keeping the total size of the app below 100 MB. Additional content, like pictures or sound files, will further restrict the data storage available to the files containing the virtual animals.

Ambition 3: Accurate: For models that are very realistic in their imitation of reality, inaccurate details are more noticeable than for less lifelike representations [19]. Since this observation concerns animations in particular, it is important to consider their use carefully in terms of effort and benefit. As animations in our case mainly serve to make the virtual birds appear more alive, we decided against the use of more elaborate animations, since minimal movements suffice. This decision saved us a lot of time, which allowed us to create the simple animations more carefully.

Although we have a lot of experience in modeling and texturizing 3D models, sculpting the virtual birds was a very time intensive procedure. Thus, this method may not be suitable for low-budget environmental initiatives. Photogrammetry, in contrast, offers a workflow which is mostly automatable. It relies on a collection of pictures of the animal that we aim to recreate. Especially rare animals are often taxidermized to be exhibited in natural history museums. This allowed us to take hundreds of photos of a specimen from different angles without the subject changing its posture. A photogrammetry software calculated a texturized 3D model from these pictures, which was then optimized for the animation and use in AR. All in all, photogrammetry accelerates the creation process of 3D models severely.

Our approach of using AR to raise awareness of rare animal species, which are barely noticed by the population, has proven to be promising and realizable. Using modern software, the 3D models of the animals can be created with reasonable effort and made available via an app. This is just one of the opportunities AR offers as a communication strategy for environmental communication.

## 6. Future Work

Before the final implementation of the virtual content can begin, our previous results must be evaluated in a user survey. This will show us how different target groups react to the virtual birds and which refinements are necessary. During the conception of the AR App, we deliberately decided not to give the user the possibility to interact with the virtual bird (e.g. by buttons, gestures or noises). By doing so, we wanted to prevent the virtual bird from being perceived as a toy. More research is needed to substantiate or contradict this hypothesis.

Furthermore, we will examine the integration of sound, since this entails another step to a lifelike presentation of the virtual animal [20].

In the future, we would also like to test other possible scenarios for AR and evaluate, whether and how they can be used for environmental communication. This includes markerless and location-based tracking to embed content without a visual marker in order to point out features in the landscape and make navigation easier.

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