A COMPUTATIONAL MODEL FOR VISUAL METAPHORS
Interpreting Creative Visual Advertisements

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Abstract: Coming up with new and creative advertisements is a sophisticated task for humans, because creativity requires breaking conventional associations to create new juxtaposition of familiar objects. Using objects in an uncommon context attracts the viewer's attention and is an effective way to communicate a message in advertisements. Perceptual similarity seems to be a major source for creativity in the domain of visual metaphors, e.g. replacing objects by perceptually similar, but conceptually different objects is a technique to create new and unconventional interpretations. In this paper, we analyze the role of perceptual similarity in advertisements and propose an extension of Heuristic-Driven Theory Projection, a computational theory for analogy making that can be used to automatically compute interpretations of visual metaphors.

1 INTRODUCTION

Visual metaphors can often be found in advertisement, caricature, and fine arts (Forceville, 1996; Carroll, 1994; Hausman, 1989). Generating novel and eye-catching visual metaphors is a highly sophisticated task requiring creativity, because their underlying meanings are crucially based on unconventional conceptualizations and the detection of new associations. Even interpreting such metaphors requires creativity (Indurkhya 2007).

Perceptual similarity seems to play a major role in visual metaphors. Mapping objects of a source to objects of a target domain based on their common visual appearance helps to bridge the gap between incompatible conceptualizations and anchors the interpretation of their metaphorical relation.

The cognitive mechanism of deliberate deconceptualization, which is needed in order to establish a new conceptualization, is a difficult task, because humans are constrained by conceptual associations that are learned during lifetime. Furthermore, it requires a significant amount of cognitive effort to break away from these associations. Computers, on the other hand, do not have such conceptual associations of their own accord and therefore they can be helpful in finding and interpreting creative metaphors (Indurkhya 1997). Our aim in this paper is to design computational systems that can model the process of interpreting visual metaphors.

The remainder of this paper is structured as follows: in section 2, we present related work on modeling creativity in visual analogies and metaphors. Section 3 exemplifies creativity and visual metaphors in the domain of advertisements. In section 4, we introduce "Heuristic-Driven Theory Projection", a formal framework developed for analogy making. We explain how this framework can be adapted to analyze visual metaphors and provide a creative interpretation. Section 5 illustrates the application domain of our approach with several examples. Section 6 concludes the paper.

2 RELATED WORK

There have been many approaches to modeling analogies and creativity underlying them. Hofstadter (1995) persuasively argued that the processes of generating representations and mapping are intimately intertwined in creative analogies.

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O'Hara and Indurkhya (1995) modeled the interaction between representation and mapping in the domain of geometric analogies. Dastani, Indurkhya and Scha (2003) proposed an algebraic model to formalize this interaction in the Copycat domain of Hofstadter. However, all these approaches are limited to artificial and rather simple domains such as letter strings or geometric figures. These domains have the advantage of being controllable so that the formal models can be systematically evaluated, but they do not scale up to the wide range of examples in ads, art and media.

There have been some studies of cognitive mechanisms underlying creativity (Gordon, 1961; Schön, 1963; Rodari, 1996). What they all agree on is that the key step is to break the conventional conceptualization of a given object or situation. Rodari also emphasizes that one needs to get closer to the perceptual image of the objects and create a resonance between the images of the source and the target. Creating strange juxtaposition of familiar objects, ignoring their conceptual properties and focusing on perceptual and visual appearance only is one way to break the existing associations, and discover new and meaningful interpretations.

Even in language-based metaphors, perceptual resemblance has often been the basis for understanding metaphorical expressions. For instance, the following lines from the poem *Seascape* by Stephen Spender:

There are some days the happy ocean lies
Like an unfingered harp, below the land ...

Here the metaphorical relation between an ocean and the unfingered harp can only be established at a perceptual level, where the sunlight reflected on the ripples of a calm ocean, making them look like the strings of a harp. Such synergy of perceptual images is essential in understanding the meaning of the poem. This is very difficult, if not impossible, to obtain by conceptual analysis alone (Indurkhya 1992; Indurkhya et al. 2008).

3 CREATIVITY AND VISUAL METAPHORS IN ADS

Many visual metaphors rely on perceptual similarity. Coming up with attractive and effective advertisements is a difficult and highly creative process. Figure 1 and additional figures in section 5 show advertisements promoting different products or ideas. They may serve as examples for how the perceptual similarity of objects is used to visualize and communicate a message.

Figure 1: Advertisements for "Clorets", a chewing gum that is supposed to help eliminating mouth odors.

Obviously, the visual appearance of objects plays a major role in the creation of the advertisement depicted in Figure 1. In the beginning, the associated objects – tongue and sock – are not similar at all, although the depicted sock appears in Figure 1 where usually the tongue would be expected. The perceptual similarity together with the contextual embedding of the sock in the mouth of a person is the starting point to establish an association between two objects, which is moved in a second step to a conceptual level. The (conceptual) similarity can only be *created* by the metaphorical comparison (Indurkhya 1994). The feature "bad odor" of a tongue might be (in principle) known before, but it is new from the cognitive agent's point of view: it is newly created in the cognitive agent's mental representation of the tongue.

It is important to notice that – based on and triggered from the visual appearance of the two initially incomparable objects – a transfer of properties from the concept "sock" to the concept "tongue" can be realized that yields a plausible interpretation of this advertisement. This transfer of properties is the basis for a creative and non-conventional interpretation of the advertisement.

4 COMPUTATIONAL MODEL FOR VISUAL METAPHORS

Metaphors, like analogies, are established via associating certain elements from the source domain with elements from the target domain. Via establishing an alignment between elements, which at the first sight are not very similar, knowledge about the elements in the source domain can be transferred and applied in the target domain and lead to a new conceptualization of the target domain.

4.1 Heuristic-Driven Theory Projection

Heuristic-Driven Theory Projection (HDTP) is a formal theory for computing analogical relations between a source and a target domain. HDTP has a logical basis: the source and the target domain are formalized as theories based on a many-sorted first-order logic. It computes analogies by associating constants, functions, relations, and (complex) formulas between target and source domain. Besides analogies, it was also applied to learning linguistic metaphors in the domain of technical devices (Gust et al. 2007). In the following, we explain how HDTP can be extended to analyze visual metaphors.

HDTP uses anti-unification to identify common patterns in the source and target domain. Anti-unification (Plotkin 1970) is a syntactical operation that compares two terms and identifies the most specific generalization subsuming both terms. More precisely, anti-unification of two terms t_1 and t_2 can be interpreted as finding a generalized term t of t_1 and t_2 which may contain variables, together with two substitutions θ_1 and θ_2 of variables, such that $t\theta_1 = t_1$ and $t\theta_2 = t_2$. Because there are usually many possible generalizations, anti-unification tries to find the most specific one. Based on the classical theory of anti-unification of terms, HDTP extends this approach to allow also the anti-unification of formulas of a first-order logical language (Krumnack et al. 2007). This results in the possibility to generalize whole theories of two given domains in order to generate a structural description of the underlying commonalities.

Figure 2 shows two examples: *f(a)* and *f(b)* are anti-unified to *f(X)* where *X* is a variable replacing the different arguments of the function. The second example shows a simple form of second-order anti-unification: *f(a)* and *g(a)* are anti-unified to *F(a)*. The different function symbols are replaced by a variable, while the common argument remains.

Given two theories Th_S and Th_T modeling source and target domain as input, the HDTP algorithm computes the analogy between the two domains. Due to the limited space, Table 1 roughly sketches the algorithm. A detailed specification of syntactic, semantic and algorithmic properties of HDTP can be found in (Gust et al. 2006; Schwering et al. accepted).

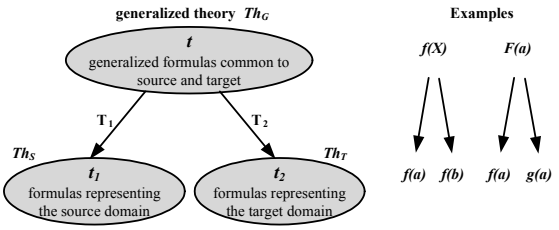

Figure 2: Establishing the analogical relation between the source theory Th_S and the target theory Th_T and constructing the general theory Th_G.

Table 1: The HDTP Algorithm to compute analogical relation between a source and a target theory.

Input: A theory Th_S of the source domain and a theory Th_T of the target domain represented in a predicate logic language.

Output: A generalized theory Th_G such that the input theories Th_S and Th_T can (partially) be reestablished by substitutions.

Algorithm: Selection and generalization of facts and rules. Select an axiom from Th_T according to a heuristics *h*. In HDTP, this heuristics could select formulas according to their complexity, i.e. prefer less complex literals to complex rules. Afterwards, select an axiom from Th_S and construct a generalization (together with corresponding substitutions).

Optimize the generalization w.r.t. a given heuristics and update Th_G w.r.t. the result of this process. The heuristics used by HDTP orders the generalizations according to the complexity of their substitutions (e.g. length of substitutions).

Transfer (project) facts and laws of Th_S to Th_T provided they are not generalized yet. Test (using an oracle) whether the transfer is consistent with Th_T. This can be done via experiments or using world knowledge in a database.

4.2 Visual Metaphor Formalization

Knowledge about the source and the target domain must be captured formally to enable a computational model to analyze metaphors. HDTP is a logical framework using first-order logic as representational language. In order to establish a metaphorical relation between “sock” in the source domain and “tongue” in the target domain (Figure 1), HDTP requires a specification of the involved domains. The main extension to the standard HDTP formalizations is the distinction in facts referring to the visual appearance and other conceptual facts that refer to the non-visual background knowledge.

We capture the shape at different levels of detail: at the very basic level we distinguish regions, lines and points. A line can be further described as being linear or curved, regularly curved like waves or irregularly curved. A region can be approximated by different mathematical attributes like quadratic, rectangular, circular, and oval. Perceptual similarity is a multifaceted phenomenon: besides common shape, it might be caused by common color, texture, or sometimes by a similar spatial arrangement of objects. Of course, the simple description of the appearance in the following tables is incomplete, but for this introductory example it should suffice.

Table 2: Formalization of the source domain.

Sorts

```
object:sock,
object:nose
property:bad,
property:region …
```

Facts referring to visual appearance

```
shape(sock, region)
in(mouth, sock)
above(nose, mouth)…
```

Facts referring to conceptual properties

```
function(sock, keepWarm)
function(sock, provideComfort)
odor(sock, bad) …
```

Table 2 describes the knowledge about socks: at the level of visual appearance, a sock has a regional shape. Furthermore, spatial properties of parts of the face can be covered, e.g. that the nose is above the mouth and the sock is in the mouth. Conceptual background knowledge about socks is crucial, because certain facts about the source domain need to be transferred and applied to the target domain and will provide the creative interpretation of the metaphor. The background knowledge is usually very large. The essential information to interpret this metaphor – the smell of the sock – must be included in the conceptual facts to come up with the correct interpretation.

Table 3: Formalization of the target domain.

Sorts

```
object:tongue,
object:nose
property:region,…
```

Facts referring to visual appearance

```
shape(tongue, region)
in(mouth, tongue)
above(nose, mouth) …
```

Facts referring to conceptual properties

```
---
```

A tongue is also described by properties referring to its visual appearance. The visual appearance can be rather similar to socks: the tongue also covers a region that can be approximated by a polygon, and it has a uniform texture. The tongue is in the mouth. Furthermore, some visual information about the context, i.e. the face in which the tongue appears, may be available. Although humans have much conceptual knowledge of tongues, the target domain contains no facts referring to conceptual properties of the tongue. This is left empty, because existing conceptual knowledge could only distract from establishing new creative knowledge. It is necessary for the deconceptualization which is essential for the interpretation of the metaphor.

4.3 Computation of Visual Metaphor

The process of analyzing visual metaphors covers the same steps as the usual analogy-making process on which HDTP is based: the retrieval of an appropriate source domain, the mapping of the analogous elements and the transfer of potentially meaningful knowledge from the source to the target domain. The difference between ordinary analogies and visual metaphors lies in the mapping process: it is the perceptual similarity between two objects which causes humans to establish a metaphorical relation. In visual metaphors, the mapping is based purely on the visual properties. HDTP restricts the anti-unification to facts referring to visual appearance only. Afterwards, in the transfer phase, HDTP focuses on facts referring to conceptual background knowledge and transfers non-visual conceptual properties. Figure 3 illustrates the process with the "Clorets" advertisements introduced in section 3. The combination of the face with a sock as the tongue can be interpreted with an analogical mapping between sock and tongue.

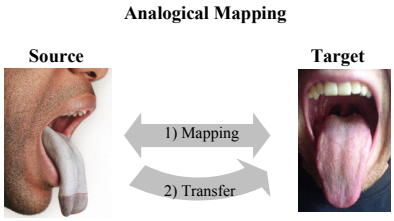

Figure 3: The visual metaphor can be interpreted via analogical mapping between a sock and the tongue.

HDTP goes through all facts describing the visual appearance of the target domain and searches successively for alignable facts describing the visual appearance of the source domain. Suitable facts are

those which can be anti-unified and lead to the most specific generalization with a minimal set of substitutions. HDTP re-uses existing substitutions and tries to minimize the overall number and complexity of substitutions. In the running example, the anti-unification process is executed as follows: The first axiom from the target domain `shape(tongue, region)` is aligned with `shape(sock, region)` from the source domain and generalized to `shape(X, region)` where the variable *X* is substituted by *tongue* on the target domain and by *sock* on the source domain. The next formula chosen from the target domain for anti-unification is `in(mouth, tongue)`. The counterpart in the source domain is `in(mouth, sock)`. In this case, HDTP reuses the already established substitutions and generalizes both formulas to the formula `in(mouth, X)` where *X* is the same variable as before. This process is continued. The more visual properties can be mapped, the more perceptually similar are both objects. The mapping phase is finished if no visual property is left in the target domain which is not anti-unified or if no suitable mapping can be created.

The second phase is the transfer of conceptual knowledge. Conceptual knowledge about socks is usually quite extensive, but only very few facts make sense in the context of this metaphor. Function aspects of socks – e.g. keeping feet warm and providing comfort – are not applicable to tongues. However, bad odor of socks is applicable and therefore a candidate for the analogical transfer. HDTP transfers every fact referring to the conceptual properties and checks afterwards for their applicability. This can be tested by an oracle that checks the compatibility (consistency, saliency etc.) of the transfer. Of course, such decisions require a spelled-out and large database of background knowledge about the target domain.

5 APPLICATION SCENARIOS

The following pictures show different advertisements for or against a product or an idea. Their interpretation originates in some kind of perceptual similarity. HDTP in the modified version as described above is a promising approach to establish a creative interpretation of these visual metaphors. This approach can be used to automatically interpret advertisements, but also to support ad designers to come up with creative ideas.

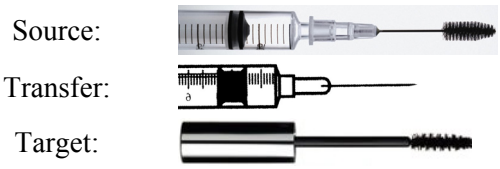

Figure 4: The advertisement associates a mascara wand applicator with a needle. It calls out on boycott of animal-tested products.

Figure 4 shows an object which is a combination of a syringe and a mascara wand applicator. Both objects share the same overall longish shape, a cylindrical tube and a spiky top. The object also has the typical features of the mascara wand applicator and the needle: the needle of the syringe with the brush at the top of a mascara wand applicator. Based on the perceptual similarity, a mapping between the syringe and the wand applicator is established. While mascara is associated with beauty, a syringe is associated with illness or even death. In the metaphorical interpretation, associated properties of the syringe are applied to cosmetics.

Figure 5: With this advertisement "Crafted from Nature" the natural origin of the material is stressed.

Figure 5 shows on the left an advertisement for cotton shirts: an orange leaf with the shape at the top resembling a collar of a shirt. The rain pearls on the leaf representing the freshness and the pure nature while the association to clothes is only created via the perceptual similarity. Note that leaves do not look like shirts in general, but they can be presented in a particular shape to look similar to shirts. The leaf characteristics are the arrangement of veins and the typical autumn color.

Figure 6 shows an advertisement against smoking. The shape of the "smoke-bag" resembles a plastic bag. The deathly effect of a plastic bag put over a head is applied to smoking. The pictures on the right show smoke of a cigarette and a plastic bag to illustrate the perceptual similarity. Here again, the perceptual similarity is on two different levels: while the material of the bag is made out of smoke (mouth and the nose of the little boy breathing the smoke), the shape resembles a plastic bag.

Figure 6: The advertisement on the left shows a small child choking on a plastic bag made of smoke. It states "Smoke isn't suicide. It's murder."

6 CONCLUSIONS AND FUTURE WORK

Perceptual similarity seems to play a major role in the generation and interpretation of visual metaphors: Two conceptually different objects are associated with each other due to their similar appearance. Based on this new alignment, conceptual properties of the source can be transferred and applied to the target, which enables a completely new, metaphoric interpretation of the target. In this paper, we suggest a formal framework to analyze metaphorical relations: HDTP computes an interpretation via a mapping based on common facts describing the visual appearance. Afterwards it transfers conceptual properties.

Further research shall investigate at a broader level what influences perceptual similarity and how it can be formalized. A set of properties describing the visual appearance will be defined. The domain of visual ads is suitable for analyzing creativity in visual metaphors, because it is as challenging as fine arts, but simpler and better structured. This eases the evaluation of a computational system. The interpretation of visual metaphors will be compared to human interpretations.

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