Modelling Divergent Production: A multi-domain approach

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Abstract
This paper presents an ongoing Ph.D. work on the area of Cognitive Modelling and, more specifically, about computational applications of theories of creativity. Without making claims to psychological views or results related to the mentioned theories, this work is concerned with a search for "different" solutions in a heterogeneous knowledge base composed of structures from a variety of domains. These structures and work upon them, in addition to a computational model of creative production, which is derived from the theory of divergent production [4], form the basis of this work. Its first applicational goal is to implement a system that generates musical ideas recurring to high-level abstractions from other domains (visual arts, story plots, architecture). Part of this has already been implemented and first results obtained.
The overall architecture is described in the present paper.

Introduction

One of the most difficult capabilities to model in a computer is our ability to create ideas. Maybe because we don't know exactly how does it happen, creativity is guarded by a mystic aureole. Although we don't propose ourselves to demystify creativity or to achieve important results to psychology research, we find interesting to work on creativity and, primarily, to study ways of allowing a symbolic manipulation machine to achieve it.

In works related to this from the area of cognitive psychology, like in [6], our capacities of abstraction, symbolic analysis, of finding not-so-obvious relations, among others, are associated to creative production. Indeed, many important discoveries, great music pieces or paintings were reportedly "achieved" in moments of divagation in domains not directly related to the referred problem (e.g. the famous dream of Kekulé, the discoverer of the structure of the Benzene molecule, that was dozing by the fire and dreaming of self-biting snakes when he made his major discovery [1]; Heitor Villa-Lobos compositions based on the "shape of a mountain" [5]). One of these cognitive psychology theories [4] concentrates itself on the idea of "divergent production".

Searching for "different" solutions

Integrated on a major "encapsulated" concept - the Structure of Intellect - Guilford considers *divergent production* as the ability to "generate variety and amount of information; most involved in creative potential" [2]. More specifically, he considers that new solutions can be generated through a "transform recall", in which information is retrieved "from a partial set of cues in the memory storage and the using of this information in a new context and in novel ways. This transformed use of retrieved information is effected largely by flexibly reclassifying, reinterpreting, or redefining well-organised information within the memory storage in relation to the demands of a clearly defined problem" [8]. In other words, this divergent production is achieved by applying different contexts to the same information in order to fit the problem in question. Of course, this can only be possible if one treats this new information through a different way, restructuring its relations with the world and within itself. This restructuring means forgetting rules (e.g. Shoenberg and his compositions based on atonality), seeing from different viewpoints (e.g. Why should the sun go around the earth, asked Galilee), applying metaphor (e.g. Icaro thought he could *be* a bird, he was creative, although not very fortunate…).

One of the main goals of our work is to apply, as far as possible, some of these ideas in order to create "something that creates something". For a start, we chose two domains (Music and Visual Arts) where it would be coherent to think of "mixing" ideas as a possible source of ideas. We don't want to interpret music as if it was a painting or vice-versa, and it would possibly be unfruitful to "force" correspondences. But, in a more abstract level, intersection of these domains is not an empty set. Concepts like tension, style, symmetry, harmony, colour, rhythm, just to name a few, are ubiquitous in these forms of art. Furthermore, musical pieces and drawings can both be represented by structured representation. One example of this, in music, is an analysis of a piece, which is a (not always strictly) hierarchical representation and, in a drawing, one can decompose it as a hierarchy from "the general image" to its smallest motives. Meanwhile, associations like tension-relax, asymmetry-symmetry, contrast-repetition are common abstract relations in both domains. Historically, each style and its specific characteristics were not confined to a single form of art. It was always spread to others. It is this spreading of ideas that we want, as far as possible, to model.

For that, we are focusing primarily on structure of knowledge and on techniques of working with it. Then, we intend to deal with problems of cross-domain connections in order to allow getting "far away" ideas. The architecture of this model will be presented in the next section.

The architecture

The organisation of this system has five main modules (fig1).

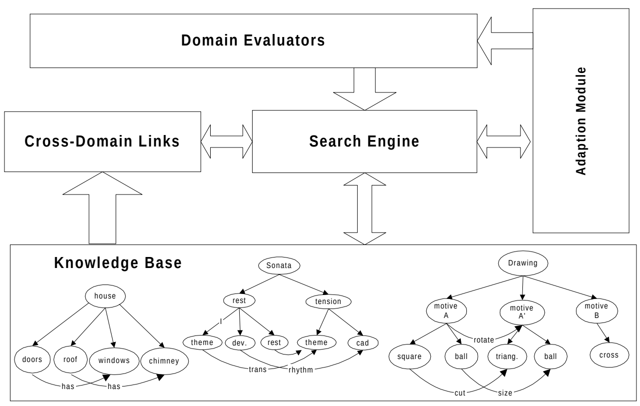

Fig.1

Knowledge Base – Set of structures from a variety of domains. These structures must be tree-like and may have links between any pair of nodes.

Search Engine – This is the core of the system. According to what is specified at the moment, the search engine tries to find solutions in the knowledge base. Following paths in the cross-

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domain links module, it jumps from domain to domain, driven by the initial specification.

Cross-Domain links – Composed by two levels of information: domain ontologies and conceptual nets. The ontologies specify explicitly knowledge about each domain (e.g. each form of Art has an associated Media; each Music has a Style; a Tonal piece of Music has a main tonality associated, etc.). Conceptual nets are freer than the ontologies in the sense that they allow links between any two concepts. These nets allow inter-relations among what is described in the ontologies and with external concepts (e.g. tension in music is associated to harmonic dissonance).

Domain Evaluators – These modules contain rules and algorithms for evaluation of the acceptability of the new structures. Far from being based on aesthetic judgements, these focus on form and structure of the related domain (e.g. in music, if trying to compose in a tonal style, the piece must finish with a well-defined harmony; in a drawing, one cannot draw outside the borders, etc.)

Adaptation Module – This module has two kinds of adaptation: domain independent and domain dependent. Domain independent adaptation forces new solutions to respect generic conditions (e.g. consistency in father/son connections, no links to non-existing nodes). Domain dependent adaptation uses domain specific rules and techniques.

Of course, there are pertinent questions to pose at this point. First, what does the Search Engine do? What are we searching for? As referred before, we are dealing with structured knowledge (like musical analysis, drawings, etc.) and a "problem" is to create new knowledge which means a new structure, be it from scratch or transforming an existing one (e.g. an architectural plant).

Another question is: How are the domains related in cross-domain links? How can this help in the search? This is a very complex problem because we want to avoid blind search through a knowledge space almost (if not completely) full of irrelevant information for the structure which is being built at the moment. On the other hand, we need to keep some freedom to allow divergent production. The present solution takes also structure as its base. For each domain, there is an ontology that describes *universal knowledge* related to it, and for each small structure, a specific conceptual net (e.g. concepts related to a specific piece of music). There may be other conceptual nets associated to generic knowledge of the domain. For establishing links (cross and intra-domain), we are following ideas of [8], from their work on the metaphor field, which presented (among other things) a system that interprets metaphors with the help of spreading activation in conceptual nets related to both domains in question (the *tenor* and the *vehicle*). For an example like "My Surgeon is a Butcher" (Surgeon - tenor; Butcher - vehicle), it connects two webs, yielding a new set of links between related concepts (Scalpel to Cleaver; Precise to Clumsy; Theatre to Abattoir, Human Flesh to Meat; etc.) coherent with the referred metaphor. With this, we want to guide our inter-domain search by establishing possible "metaphorical" parallels between concepts (e.g. tension and style in music and tension and style in paintings).

Another different problem that rises is "what to do with this information?". We want to use these new "metaphors" to find structures from other domains (nodes, sub-trees) and then adapt them to the new demand. This is done by "forgetting" domain properties of its origin or replacing them by their "metaphorical" correspondents but, above all, maintaining their structure (connections with the context: number of descendants, links to antecedents and consequents).

Ongoing Work

The first implementation step of this work is to build a program that uses structures of the two referred domains (music and visual arts) to generate new musical structures. This program is named "Dr. Divago" and is expected, in a final version, to be able to "divagate" through other domains. The "single domain" generator cycle has been entirely developed. And the first results appeared. It creates harmonic sequences by using musical analyses from memory. The drawing module is presently being constructed. Then, the immediate work is to "join" drawing structures and create cross-domain links as described before.

Conclusions

This paper presented the overall architecture and theoretical background behind a Ph.D. work on computational creativity. As in other works, it is natural that implementations and further investigations mutate the original idea gradually until getting the final result. But we think this is a rather mature framework at least in what concerns to the idea of working on structures and using "metaphorical" connections between conceptual webs to search for "far away" domains. The authors have already achieved some confidence on working on the generation of musical structures using CBR in previously published work.

Without aiming to obtain results of excellence in the creation of artworks, we hope to shed some light on the search for "different" solutions in Artificial Intelligence.

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