Chapter 11

A Smallest Grammar Approach to the Symbolic Analysis of Music

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ABSTRACT

In this chapter we discuss symbolic analysis of music using grammars, and present a novel approach to such an analysis, in which a compressive grammar is automatically generated explaining a musical work’s structure. The proposed method is predicated on the hypothesis that the shortest possible grammar provides a model of the musical structure which is a good representation of the composer’s intent. The effectiveness of our approach is demonstrated by comparison of the results with previously published expert analysis; our automated approach produces results comparable to human annotation. We also illustrate the power of our approach by showing that it is able to locate errors in scores, such as those introduced by OMR or human transcription. Further, our approach provides a novel mechanism for intuitive high-level editing and creative transformation of music. A wide range of other possible applications exists, including automatic summarization and simplification; estimation of musical complexity and similarity, and plagiarism detection.

INTRODUCTION

Art is something that we understand poorly. Progress in art is typically based on intuitions, heuristics, rules of thumb, experience, tradition, habits, guesswork, examples, or imitation. In contrast, engineering, in the broadest sense, is something that we understand well. It is unsurprising that we often colloquially
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refer to fields of engineering that are not yet fully formalised to our satisfaction as being “art”. Progress in engineering predominately stems from rigorous mathematical and computational formalisation: models, methods, algorithms, laws, theorems — these are the tools which enable clear understanding of problems, analysis and synthesis of complex things, and efficient communication of ideas.

The progress of our civilization has witnessed many fields transitioning from initially being an art to becoming a form of engineering. David Deutsch in “The Fabric of Reality” (Deutsch, 1997) wonderfully illustrates this with an example from architecture. Medieval structures (very few of which, such as some cathedrals, have survived the test of time) were constructed by the process of “art.” A master builder, endeavouring to build a cathedral or a bridge, would rely on a complex collection of intuitions, rules of thumb, and traditions learned as an apprentice from the builder’s master. Novel structures could only be conceived by slightly altering an existing design (for example, adding one more storey to a building). Deutsch (1997) argues that, through development of rigorous theories with high explanatory power (in mathematics, material science, computing etc.), the modern architect is equipped with a fundamentally different kind of knowledge: he or she does not merely know more facts or rules than an ancient master builder, but rather better understands how to build structures. When factual, empirical knowledge is summarised in explanatory (mathematical, computational) theories, a transition from art to engineering occurs, and this transition is a markedly qualitative one. Continuing with Deutsch’s example (Deutsch, 1997), a modern architect, because of this engineering understanding, can build all that a master builder could with far less effort, but can also build structures which a master builder could hardly have dreamt of, such as the Eiffel tower, skyscrapers, or space stations, and out of materials he has not heard of, such as fiberglass or reinforced concrete.

Another example is medicine. Ancient healers relied on observational knowledge and intuitions (stage of “art”). As medical and biochemical research progresses, rigorous theories of, for example, physiology or pharmacokinetics, allow for a qualitatively different approach to medicine (stage of “engineering”), and enable treatment methods that were inconceivable even in principle before medicine had become a form of engineering.

Similarly, aviation has also seen a rapid qualitative transition from heuristic imitation of a bird’s wing by Otto Lilienthal or the ancient Chinese traditions of building kites (“art” stage), through the development of modern aerodynamics, CAD modeling, theory of turbulence, material science, etc. to the modern, well understood, field of aeronautical engineering. Again, the transition is a qualitative one.

We believe that the time is right to seriously consider enhancing arts with the engineering perspective.

Often, attempts to apply mathematical and engineering methods to the analysis and synthesis of art are greeted with skepticism and even hostility. We hope, however, that the above examples sufficiently illustrate what benefits engineering treatment may bring to the arts. Further, we argue that not pursuing the goal of converting arts from being an art to being a form of engineering is unethical: by not doing so, we would be denying our descendants the opportunity to experience the magnificent works of art (the artistic equivalents of space stations, the Eiffel tower, MRI machines, Boeing 747s) that could be otherwise created by art-engineering.

Of all arts, music is likely to be the first one to transition into the engineering stage. It is already partially on the way: music already has a formal, universally understood language, existing semi-elegant musical theory already attempts to summarise empirical knowledge and to explain musical phenomena in rigorous terms of acoustics, psychology, and psychoacoustics. Interestingly, the fact that musicians can easily read music in real-time, stems from the fact that musical notation is a context-free language
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