Our work on Reoccurring patterns in hierarchical protein materials and music

• What we did
  o Found an analogy between certain aspects of materials and certain aspects of music (structural and functional analogies)
    ▪ Clustering strategies
    ▪ Hierarchical build-up)
  o Made it precise using CT
  o Enhanced version of ontology logs – hierarchical representation
• How we did it
  o “What’s the right way to look at this?”
  o What are the pieces and how do they fit together?
  o Look for correspondences of structure and function between two systems and record it in an olog (aim: find an functorial isomorphism)
• Why we did it
  o Data storage and sharing
    ▪ Ologs as databases
    ▪ Sharing data within and between research groups
  o Education: Humans learn and understand by analogies
    ▪ By creating your own ologs you are forced to thoroughly investigate each systems in order to propose an analogy
    ▪ Insights naturally arise from this process
      • an unexpected connection between H-bond clusters/chord structures
      • damage tolerance in protein sequences/damage tolerance in chord sequences with respect to biological/harmonic functionality
  o Finding cross-disciplinary organizing principles
    ▪ If the same olog describes multiple systems across disciplines, we can deduce overarching principles
      • Principle of attraction in chemistry, physics, and human interaction
      • Principle of lowest energy state
    ▪ Anthropomorphization is more acceptable if the analogy between the given system and human behavior is made explicit.
      ▪ Subsequently equivalent modeling techniques can be applied
• Summary:
  o MIT Charter (1861): “Established for advancement and development of science; its application to industry, the arts, agriculture, and commerce.”
  o Ologs connect these various domains, so that the tools from science can be imported and applied in the others.
Talk with Denise Brehm (scheduled for 2011/11/18 – 3:15pm)  
David Spivak, Tristan Giesa

A: a nanocomposite

B: a protein

D: a polypeptide

E: a group of amino acids

F: a bond

G: an amino acid

H: a secondary structure

J: a shear strength

B': a chord

D': a tone

E': a group of sound waves

F': a stack

G': a sound wave

H': a tonal structure

J': a pitch

A': a riff (rhythmic assembly of chords)

A': a sine wave stack cluster (SWSC)

B': a consonant SWSC

C': a sine wave stack

D': a bond

E': a pair \((R, r)\)

F': an integer \(u\)

G': an integer \(u \geq 2\)

H': a real number

D': a stack

E': a pair \((R, r)\)

F': a matrix of integers \([x_{ij}]\)

G': a matrix of real numbers \([x_{ij}]\)

H': a real number

has, as average of \(x_{ij}\)
<table>
<thead>
<tr>
<th>General Property</th>
<th>Silk</th>
<th>Music</th>
</tr>
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<tbody>
<tr>
<td>Assembly of building blocks</td>
<td>Amino acids assemble into polypeptides via polypeptide bonds</td>
<td>Sound waves are stacked and interfere</td>
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<tr>
<td>Assembly of single units</td>
<td>Polypeptides assemble via covalent and weak bonds and form secondary structures</td>
<td>Sound waves with different frequency, amplitude and pitch form notes (instrument)</td>
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<tr>
<td>Assembly of functional units</td>
<td>Silk protein is formed in a stable structure dependent on solvent condition and ionization state</td>
<td>Sound wave of consonant frequency form chords on the equally tempered scale</td>
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<td>Assembly of functional structure</td>
<td>Alanine rich repeat units form betasheets with high strength whereas glycine rich repeat units form extensible semi-amorphous phases; Repetition of functional units creates nanocomposites</td>
<td>Harmonic sequences consist of the three main functions (tonic, sub-dominant and dominant); Sequence/Repetition of chords creates a melody riff</td>
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<td>Upscaling of functionality</td>
<td>Nanoconfinement of composite structure ensures functionality (high strength, extensibility and toughness) on the macroscale</td>
<td>Phrases and climaxes within the music ensure musical tension, functional dependency of chord sequence</td>
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<td>Damage Tolerance</td>
<td>Localization of deformation upon loading provides spider webs with robustness, damage mitigation, and superior resistance by nonlinear material behaviour</td>
<td>According to the dependency structure single chords may be removed from or entered into the sequence without affecting the harmonic function</td>
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