Multimodal interaction in domain-specific communication

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Cohesion and coherence in data-processing in construction, a sub-domain of mechanical engineering

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overview

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- multimodal communication in data processing in construction
- corpus and computational linguistics
- systemic functional linguistics
- aims:
  - domain-specific types of multimodal documents
  - cross-modal cohesion and coherence
  - reception and production skills

multimodal communication in the target domain

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"A multimodal text is a text that uses several modes of communication (e.g., speech, writing, image) in an integrated way to convey a message or content."

(Kress, van Leeuwen 2001)

multimodal communication in the target domain

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- target domain: data processing in construction, a subdomain of mechanical engineering
- self-characterisation: „the drawing is the language of the engineer“ (Reiner Anderl)
- modes:
  - natural language
  - formulae
  - visual representations such as pictures, schematic figures, sketches etc.
  - intermediary forms: tables, representations of data structures
  - virtual models such as CAD (Computer Aided Design) models

multimodal communication in the target domain

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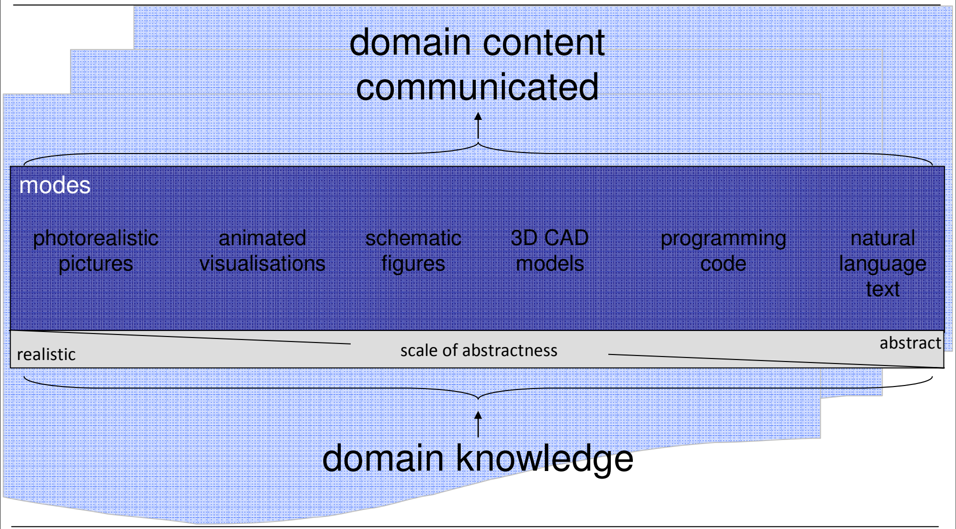

multimodal communication in the target domain

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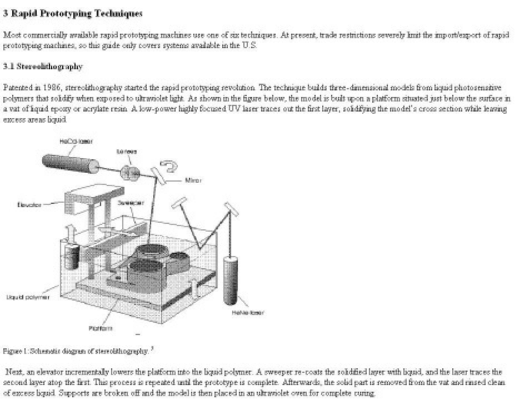
- types of written communication artefacts:
  - printed documents (books, journals, papers, reports)

  computational communication artefacts:
  - electronic documents (webpages, online papers, pdfs)
  - visual and virtual 2D and 3D construction models
  - intermediary types (3D pdf)
  - user interfaces (databases, product data management systems, CAD construction software)
  - databases (PDM, CAD development repositories)
  - ...

examples



3 Rapid Prototyping Techniques

Most commercially available rapid prototyping machines use one of six techniques. At present, trade restrictions severely limit the import/export of rapid prototyping machines, so this guide only covers systems available in the U.S.

3.1 Stereolithography

Patented in 1986, stereolithography started the rapid prototyping revolution. The technique builds three-dimensional models from liquid photosensitive polymers that solidify when exposed to ultraviolet light. As shown in the figure below, the model is built upon a platform situated just below the surface in a vat of liquid epoxy or acrylate resin. A low-power highly focused UV laser traces out the first layer, solidifying the model's cross section while leaving excess areas liquid.

Figure 1: Schematic diagram of stereolithography.[3]

Next, an elevator incrementally lowers the platform into the liquid polymer. A sweeper re-coats the solidified layer with liquid, and the laser traces the second layer atop the first. This process is repeated until the prototype is complete. Afterwards, the solid part is removed from the vat and rinsed clean of excess liquid. Supports are broken off and the model is then placed in an ultraviolet oven for complete curing.

html-page: teaching materials

pdf: model of a turbine

multimodal semiosis

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- content structure
- rhetorical structure
- layout structure
- navigation structure
- intramodal structure

Intermodal organisation

genre

form

adapted from the GeM model; Bateman et al. 2001

multimodal analysis

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- content - in terms of:
  - medium (html, jpg, wav/mp3), mode, code
  - experiential, field
- layout – in terms of:
  - arrangement of units in space and time
  - positioning of units relative to one another
  - framing or highlighting of elements
- navigation structure – in terms of:
  - hyperlinks, navigation buttons etc.
  - functionality buttons
  - bibliographical references
  - headlines, captions etc.
  - references to document external (re-)sources

multimodal analysis

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- experiential
  - lexis (terminology, collocations)
  - lexico-grammar (transitivity: process types, participants, circumstances)
- interpersonal
  - interactivity (active linking, document manipulation by the recipient)
- textual
  - cohesive relations
- logico-semantic relations
  - expansion, projection
- status
- rhetorical structure
  - further specification of logico-semantic relations: concession, opposition, disjunction, problem-solution, cause-consequence, proposal-evidence, events-generalization, etc. (Mann & Thompson 1987)

Rhetorical structure	Rhetorical Structure Theory (RST; Mann, Thompson 1987): elaboration, purpose etc.
Conjunctive relations	Markers for spatial-temporal relations: *then, in the next step;* Contribution to textual cohesion
Cohesion	Anaphora resolution (e.g. **These "three dimensional printers** ….“ “**They** make …”)
Generic structure	Overarching discourse relations; Contribution to textual coherence Generic Structure Potential (GSP; Hasan 1985/1989a, b)

multimodal cohesion and coherence

- different modes jointly contribute to multisemiosis, i.e. the process of meaning-making in multimodal documents
- cohesion:
  - verbal cohesion
  - visual cohesion
  - cross-modal cohesion
- coherence

  subject to interpretation by the recipient

multimodal analysis

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- formulae, programming code
  - highly conventionalised, abstract representations
  - cohesive ties (bracketing, lexical repetition etc.)
- features for intramodal analysis of other modes?
  - highly conventionalised schematic figures, flowcharts
  - conventionalised forms of data presentation such as tables
  - data-driven visual and virtual represenations such as 2D and 3D CAD models
  - metadata descriptions of objects, processes and circumstantials in images, photographs, schematic figures

cross-modal cohesion

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- simple repetition
- complex lexical repetition (shared a lexical morpheme, but no formal identity) |
  ex.: prototype - prototyping – prototyped
- simple mutual paraphrase
- simple partial paraphrase
- other complex paraphrase
- [antonymous complex paraphrase]

Hoey 1991

cross-modal relations: status of modes

- relative **status** of modes
  - text supporting image (*anchorage*),
  - image supporting text (*illustration*),
  - text and image equal / complementary (*relay*)

(Barthes 1977)

- equality | unequality

(cf.also Martinec, Salway 2005)

cross-modal relations: status of modes

- status
  - equal
    - image & text independent
    - image & text complementary
  - unequal
    - image subordinate to text
    - text subordinate to image

cross-modal relations: logico-semantic relations

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- logico-semantics:
  - expansion:
    - elaboration (elaboration on the meaning of another unit by a more detailed description of it)
    - extension (extension of the meaning of another unit / mode by adding further, related information)
    - enhancement (of a mode by qualifying it in terms of time, place, cause, and other circumstantial meanings)
  - projection

⇨ possibility of extension of these relations to further discourse units and other modes such as images, tables, formulae, 3D models etc.

cross-modal relations: logico-semantic relations

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- expansion
  - elaboration
    - exposition: i&t same level of generality
    - exemplification
      - text more general
      - image more general
  - extension
  - enhancement
    - temporal
    - spatial
    - conditional
    - causal (reason | purpose)
    - comparative
    - concessive

cross-modal cohesive clusters: objects in different modes

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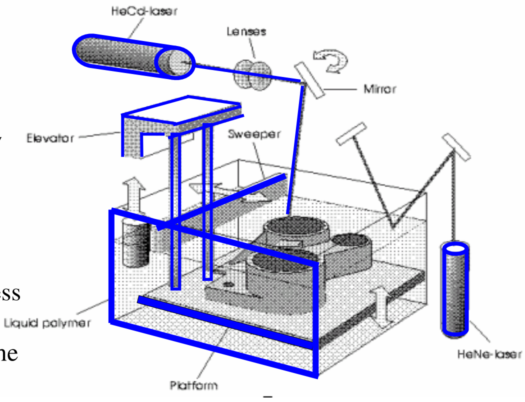
The technique [stereolithography] builds three-dimensional models from liquid photosensitive polymers that solidify when exposed to ultraviolet light. As shown in the figure below, the model is built upon a platform situated just below the surface in a vat of liquid epoxy or acrylate resin.
A low-power highly focused UV laser traces out the first layer, solidifying the model's cross section while leaving excess areas liquid. Next, an elevator incrementally lowers the platform into the liquid polymer. A sweeper re-coats the solidified layer with liquid, and the laser traces the second layer atop the first.



text more general than image

cross-modal cohesive clusters: processes in different modes

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The technique [**stereolithography**] builds three-dimensional models from liquid photosensitive polymers that solidify when exposed to ultraviolet light. As shown in the figure below, the model is built upon a platform situated just below the surface in a vat of liquid epoxy or acrylate resin.
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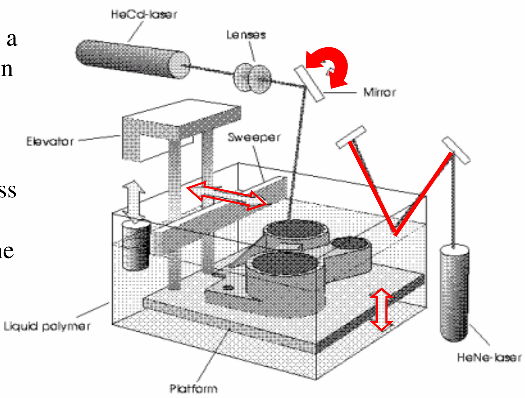
image more general and unspecific than in text



Generic structure

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1 Overview of Rapid Prototyping
The term rapid prototyping (RP) **refers to** a class of technologies that can automatically construct physical models from Computer-Aided Design (CAD) data. These "three dimensional printers" **allow** designers to quickly create tangible prototypes of their designs, rather than just two-dimensional pictures. Such models **have** numerous uses. They **make** excellent visual aids for communicating ideas with co-workers or customers. In addition, prototypes can be **used** for design testing. For example, an aerospace engineer might **mount** a model airfoil in a wind tunnel to measure lift and drag forces. Designers have always **utilized** prototypes; RP allows them to be made faster and less expensively.

:

Relational processes e.g. in definitions etc.

Material processes e.g. in explanations and examples

cross-modal clustering

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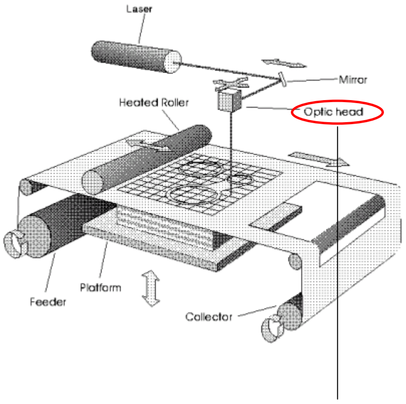


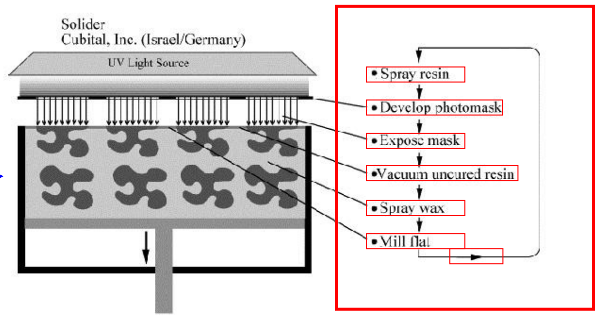
ellipsis in text

As shown in the figure below, a feeder/collector mechanism advances the sheet over the build platform, where a base has been constructed from paper and double-sided foam tape. Next, a heated roller applies pressure to bond the paper to the base.
A focused laser cuts the outline of the first layer into the paper and then cross-hatches the excess area (the negative space in the prototype). Cross-hatching breaks up the extra material, making it easier to remove during post-processing. During the build, the excess material provides excellent support for overhangs and thin-walled sections. After the first layer is cut, the platform lowers out of the way and fresh material is advanced.

3.4 Solid Ground Curing

multi-target text-image cohesive ties

Developed by Cu C) is somewhat similar to stereolithography (SLA) in that both use ultravic hotosensitive polymers. Unlike SLA, SGC cures an entire layer at a time. Figure 5 depicts solid ground curing, which is also known as the solider process. First, photosensitive resin is sprayed on the build platform. Next, the machine develops a photomask (like a stencil) of the layer to be built. This photomask is printed on a glass plate above the build platform using an electrostatic process similar to that found in photocopiers. The mask is then exposed to UV light, which only passes through the transparent portions of the mask to selectively harden the shape of the current layer.



multimodal referring expressions

Figure 5: Schematic diagram of solid ground curing. [11]

crossmodal referring expressions

After the layer is cured, the machine vacuums up the excess liquid resin and sprays wax in its place to support the model during the build. The top surface is milled flat, and then the process repeats to build the next layer. When the part is complete, it must be de-waxed by immersing it in a solvent bath. SGC machines are distributed in the U.S. by Cubital America Inc. of Troy, MI. The machines are quite big and can produce large models.

cohesion: anaphora

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- modality:
  verbal indicative phrases in text vs.
  imperative phrases in the image

  “photosensitive resin is sprayed on the build platform”

  vs.

  “spray resin”

anaphoric referring expressions

cross-modal cohesion: conjunction in text and figure

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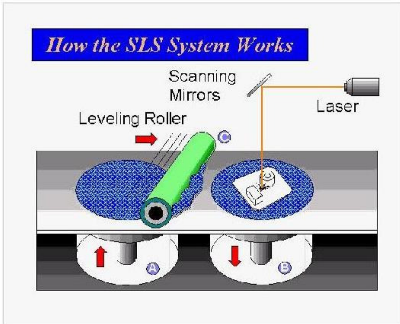
[…] solid ground curing (SGC) is somewhat similar to stereolithography (SLA) in that both use ultraviolet light to selectively harden photosensitive polymers. Unlike SLA, SGC cures an entire layer at a time. Figure 5 depicts solid ground curing, which is also known as the solider process. **First**, photosensitive resin is sprayed on the build platform. **Next**, the machine develops a photomask (like a stencil) of the layer to be built. This photomask is printed on a glass plate above the build platform using an electrostatic process similar to that found in photocopiers. The mask is **then** exposed to UV light, which only passes through the transparent portions of the mask to selectively harden the shape of the current layer.

non-explicit parallel conjunction in text and image



text as complex paraphrase of image

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teaching materials / teacher to student:
[ctd. from previous slide] As shown in the figure below, a feeder/collector mechanism advances the sheet over the build platform, where a base has been constructed from paper and doubles-sided foam tape.
Next, a heated roller applies pressure to bond the paper to the base.
A focused laser cuts the outline of the first layer into the paper and then cross-hatches the excess area (the negative space in the prototype).
Cross-hatching breaks up the extra material, making it easier to remove during post-processing.
During the build, the excess material provides excellent support for overhangs and thin-walled sections.
After the first layer is cut, the platform lowers out of the way and fresh material is advanced.
The platform rises to slightly below the previous height, the roller bonds the second layer to the first, and the laser cuts the second layer.

Scoping:
reference to larger and distributed sections
document parts

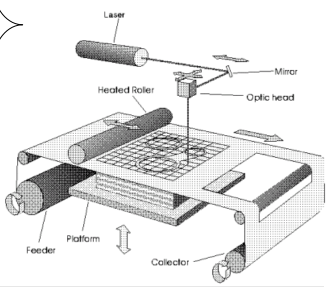

image as complex paraphrase of text

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scientific paper / expert-to-expert:

a. Laser Sintering (SLS), and their use in the HIP process to fabricate tool steel mold cavities, Figure 1.
b. The interaction of software programs necessary for Curved LOM is illustrated in Figure 2 (see [1] for an expanded description). The algorithms are incorporated in two separate packages.
c. In fact, the cured shell fit almost perfectly on a freshly-built mandrel, as illustrated in Figure 5.

interactivity and cohesion in 3Dpdf

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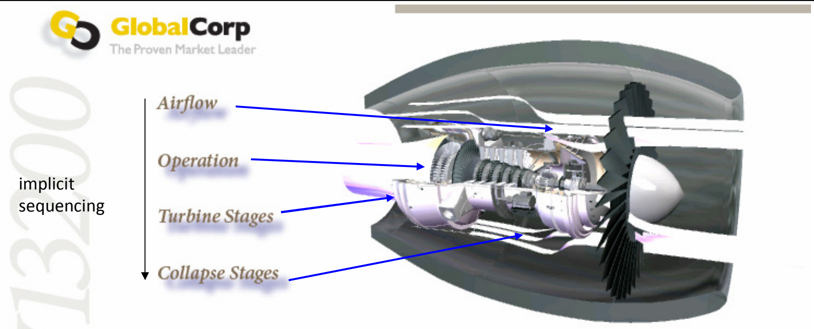
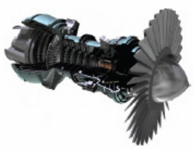
- cohesive devices:
  - repetition of terms
  - paraphrasing
  - text – construction data
  - interaction activated cohesion
- new forms of interactivity
  - user interaction with the document
  - manipulation of an image or model



implicit sequencing



Technical Specification LV3200

Fan Tip Diameter (inches)	68.5	Design RPM	13,000
Length, flange to flange	128	Exhaust Jet Velocity (ft/s)	1917
Takeoff thrust	29,000 -31,500 lb	Turbine pressure ratio (t-t)	1.9
Flat rated temperature.	86°	Efficiency (t-t%)	86.4
Bypass ratio	4.75 - 5.1	Overall pressure ratio	27 -29.8
Flat rated temperature	89°	Loading (BTU/h/ft3/atm)	1.24E+07

corpus annotation

```
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Manufacturing</unit>
<unit id="u-01.109"><xlink:href="//gemBase/unit[@id='u-
01.118']" role="text-to-image" from=„u-01.109“ to=„u-01.118“
status=„unequal-image-subord“ logsem=„enhancement-temporal“
cohesion=„complex-paraphrase“/>As shown in the figure below,
a feeder/collector mechanism advances the sheet over the
build platform, where a base has been constructed from paper
and double-sided foam tape. [see next slide] </link></unit>
<unit id="u-01.118" alt="Bilder/Figure2“ objects=„laser
mirror platform collector …“ processes=„vertical_move
horizontal_move“/>
<unit id="u-01.119">
   <xlink:extended role="caption" title="figure caption">
   <xlink:locator href="//gemBase/unit[@id='u-
01.118']"/>Figure 2: Schematic diagram of laminated object
manufacturing.</xlink:extended></unit>
```

summary and future research

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- integrated characerisation of relations between modes in multimodal documents
- new forms of interaction / cohesive devices between modes in multimodal documents
- new forms of production and reception skills by both learners and teachers

references

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- André, Elisabeth, Thomas Rist. 1994. 'Referring to World Objects with Text and Pictures.' Coling 1994.
- Bateman, John, Kamps 2001.
- Bateman, John, Judy Delin, Renate Henschel. 2002. Multimodality and empiricism: methodological issues in the study of multimodal meaning-making. GeM Report 2002/1.
- Barthes, Roland. 1977. *Image – Text – Music.* London: Routledge.
- Halliday, M.A.K; and Ruqayia Hasan (1976): *Cohesion in English*. London: Longman.
- Hoey, Michael (1991): *Patterns of Lexis in Text*. Oxford: OUP.
- Martinec, Radan, Andrew Salway. 2005. A system for image-text relations in old (and new) media. Visual Communication Vol 4(3): 339–374.