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Bridging the gap of domain and visualization experts with a *Liaison*

Svenja Simon[1] Sebastian Mittelstädt[1] Daniel A. Keim[1] and Michael Sedlmair[2]

[1]University of Konstanz, Germany
[2]University of Vienna, Austria

Abstract

We introduce the role Liaison *for design study projects. With considerable expertise in visualization and the application domain, a* Liaison *can help to foster richer and more effective interdisciplinary communication in problem characterization, design, and evaluation processes. We characterize this role, provide a list of tasks of* Liaison *and visualization experts, and discuss concrete benefits and potential limitations based on our experience from multiple design studies. To illustrate our contributions we use as an example a molecular biology design study.*

1. Introduction

Many problem-driven visualization projects such as design studies [SMM12] are heavily based on collaboration. In such projects, domain experts provide data and driving problems, and visualization experts the expertise in exploratory data analysis and visualization methods. Bringing these competences together is of utmost importance for the success of such problem-driven endeavors, necessitating not only expertise in both domains but also a good communication and a shared understanding between both groups [vW06, YKSJ08].

Communication in such exploratory data analysis projects poses specific challenges that go beyond more generic setups that are discussed in HCI or Software Engineering [Gra13]. Frist, domain problems that are tackled in visualization research are often *inherently complex* and come with a tremendous amount of knowledge that is necessary to advance these domains. Consider, for instance, application fields such as genomics [MMP09, MWS*10], security applications [MWE*15], or automotive engineering [SIB*11, PBK10]. Second, the *knowledge gap* is often high. Visualization researchers cannot acquire the necessary domain knowledge and expertise in a simple and straight-forward way because patterns of thinking and strategies for solving problems differ significantly. Third, visualization projects usually address *ill-defined tasks* that are also changed and shaped along the design processes [SMM12]; not even domain experts can easily and crisply define their problem [vW06], which further aggravates the challenge of clear communication.

While the visualization literature provides practical design and evaluation guidance on conducting interdisciplinary projects [SMM12, MSQM13, MMAM14, VFP08, AHKGF11]), there has been surprisingly little focus given to the actual communication processes necessary for such qualitative design and research endeavors. In this paper, we describe the concept of a *Liaison* role as one approach to foster a better and richer interdisciplinary communication. We first provide a simple model that can be used to reason and understand the interdisciplinary communication issue. Next, we characterize the *Liaison* and how different variations of this role can be utilized in problem-driven visualization research. The idea for the *Liaison* is based on our own experience from several different design studies where we implicitly used this role. To illustrate benefits, characteristics, and potential limitations of the *Liaison*, we will refer to a specific project, in which we have first explicitly utilized this role.

2. Related Work

The HCI community has spent a considerable amount of work on better understanding how to include users into design processes (e.g.,User-Centered Design [VMSC02]). Participatory Design goes even further and actively participates users in the design process [Spi05]. In participatory design and co-design [ALF07] also the term liaison is used. However, a clear definition is missing, a liaison in these areas usually refers to domain experts involved in the design process or to a person who gives technical support to target users. In contrast, we characterize the *Liaison* for problem-driven visualization projects as a role that abstracts domain problems for visualization experts, but do not involve domain experts actively in the design process. In the visualization community, Sedlmair *et al.* specified roles in their Design Study Method-

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ology framework [SMM12]. Their *translator* is similar to our *Liaison*, but has been merely mentioned and not been characterized. We decided to use the term "*Liaison*" to strengthen the cooperation and mediation aspect.

Independent of the kind of –broadly speaking– software design a common understanding is needed. The higher the *knowledge gap* to the problem domain, the more common understanding is needed. Bratteteig discussed mutual learning [Bra97] in this respect. Lloyd & Dykes proposed to use mutual lectures and presentations in visualization projects [LD11]. Kirby & Meyer give recommendations for successful visualization collaborations [KM13] and suggest learning the domain language. The use of the domain language and the associated domain understanding supports to capture the mental model and thereby to build intuitive visualization systems. Gaining and learning domain language and knowledge is one way to become a *Liaison* (see Sect. 4).

3. The Interdisciplinary Communication Issue

To illustrate the issues of interdisciplinary communication we propose a simple model based on a metaphor of spaces (see Fig. 1). The domain expert/s span a *Problem Space*, which comprise domain problems composed of *facets* such as domain goal, tasks, data, and constraints. The visualization expert/s (VIS team), on the other hand, span a *Design Space* of visual solutions composed of tasks & data abstractions, visual encoding & interaction techniques, and algorithms. To address a domain problem, first all its *facets* need to be understood, which requires large domain knowledge. To design a visual solution (indicated by lines in our model) different design choices need to be considered that match problem

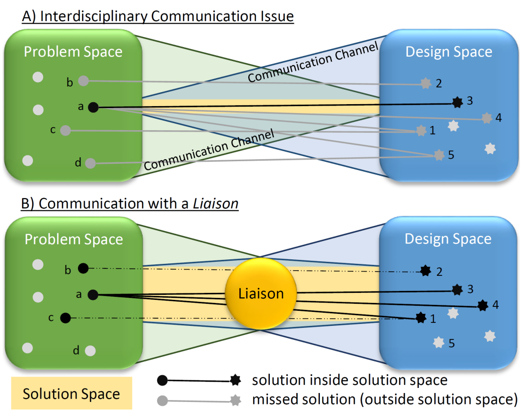

Figure 1: *The* Problem Space *comprises all domain problems and the* Design Space *all visual solutions. (A) Without a common language the domain and visualization experts communication builds a cone, leading to a small* Solution Space. *Thus, many possible solutions are missed (gray lines). (B) A* Liaison *mediates between domain and visualization experts to widen the* Solution Space, *which covers more possible solutions (1,3,4) for (a) and allows the identification of additional interesting domain problems (b,c).*

abstractions & techniques to domain problems & tasks. Thus a good solution requires both, a large domain and a large visualization knowledge. Otherwise, solutions can be composed of bad design choices and do not solve the domain problem.

Ideally one person covers both knowledge spaces, but the issue of problem driven research is that rarely one person has a grounded knowledge in two domains. Thus, typically a domain and a VIS team work together and communicate to connect the knowledge of both spaces with the aim to capture all design alternatives (solution lines) for a domain problem. Without a common understanding both communication endeavors build a cone resulting in a restricted overlap and common understanding (see Fig. 1 A). Thus, just a small part of the solution lines are contained in the *Solution Space* leading to potentially sub-optimal solutions. We denote this issue as the interdisciplinary communication issue and suggest the *Liaison* role as a solution (see Fig. 1 B) to broaden the communication channel and *Solution Space*.

4. The *Liaison* Role

The goal of the *Liaison* is to overcome the interdisciplinary communication issue. A *Liaison* shares knowledge and language with both domains for mediating between domain and visualization experts. This establishes a common understanding and greater coverage of the *Problem* and *Design Space* resulting in a larger *Solution Space* and thus a better yield of good solutions (see Fig. 1 B). The *Liaison* grasps information of the domain experts and interprets, selects and processes these for the VIS team. Therefore, the *Liaison* needs knowledge in both domains. In particular, the *Liaison* needs the domain language to allow a free speech and collaborative analysis with domain experts (see benefits, Section 5). Even though, a grounded visualization knowledge and language is beneficial, a basic understanding is sufficient. The VIS team can compensate this missing knowledge, whereas a certain domain knowledge is essential to bridge the *knowledge gap*.

How to become a *Liaison*.

There are three general ways to become a *Liaison* (see Fig. 2), which have been used implicitly, but not been reported explicitly yet. First, starting as a domain expert interested in visualization, e.g. in [MWE*15] (domain *Liaison*); second, starting as a visualization expert who gathered much knowledge in an application domain during a design study, e.g. in [SIB*11, SFMB12] (visualization *Liaison*), and third, inherently starting from an interdisciplinary subject, such as, bio-, geo-, or business-informatics (interdisciplinary *Liaison*). All three types have different advantages and disadvantages.

The domain knowledge of a **visualization *Liaison*** might not be sufficient to master the problem complexity, as gaining domain knowledge requires much time. Staying in one application domain is therefore advisable. The benefit of this *Liaison* is that the grounded visualization knowledge might allow a smaller VIS team. To broaden the *Problem Space* and to ensure that solutions match the domain problem, joint meetings with domain experts and the VIS team are recommended.

Such meetings also address the issue of focusing just on a research contribution and not on solving the domain problem.

The other extreme is the **domain *Liaison***, who might have problems to identify an interesting visualization problem, due to a small visualization knowledge. However, this *Liaison* is effective in capturing the problem complexity and in validating design alternatives of the VIS team since she focuses on a practical solution. A close collaboration with a strong VIS team is advisable who can focus on technical novelty.

The **interdisciplinary *Liaison*** has grounded knowledge in both domains, which makes her more effective in problem and task abstractions than the other *Liaison* types. The prevalence of further advantages and disadvantages depends on the current focus of the interdisciplinary *Liaison*. The interdisciplinary background is a strong advantage, since she can contribute interdisciplinary methods to improve data and analytical grounding for visualizations. Even though, an interdisciplinary *Liaison* might rarely be at hand, interdisciplinary researchers might be interested to join a project as *Liaison* and would be willing to learn more about visualizations.

Instantiations of the *Liaison* role and the VIS team. Both *Liaison* and VIS team are roles and can be instantiated in different ways. The minimal team would be a two-man-show; the *Liaison* and one visualization colleague. However, with this team instantiation the *Design Space* will be small and suboptimal-solutions are probable. A senior visualization supervisor (as VIS team) might compensate for this issue and span a "broad-enough" *Design Space*. Even though, we recommend a VIS team (several visualization experts) to ensure a broad *Design Space* and to design a visual solution. Prototyping, tool-building and paper writing can be done by one or more members of the VIS team. In any instantiation the *Liaison* works closely with the VIS team. Fig. 2 defines the tasks both roles have to perform in each design study step.

5. Benefits and tasks of the *Liaison* and the VIS team

In the following we present the *VisExpress*-project to exemplify the application of the *Liaison* role. Further, we discuss the benefits of the *Liaison* for the design study process according to concrete tasks (see Fig. 2).

Am I a *Liaison*?

- Do you have a common understanding with your domain experts?
- Can you speak with your domain experts in their language?
- Can you abstract and canalize information from their domain?
- Can you accomplish the following tasks?

General Steps	VIS team	*Liaison*
Domain Problem Characterization	• discuss promising domain problems	• select promising domain problems • characterize domain problem • capture mental model of domain experts • abstract domain problem
Abstraction	• abstract data & tasks in visualization terms	• ensure validity of abstraction with respect to the problem characterization
Design	• design visual encodings & interactions • span *Design Space*	• map mental model with design • canalize *Design Space* • span *Solution Space*
Evaluation		• clarify domain tasks further • test the fit of the mental model • clarify feature extensions and usability • capture reasoning processes
Reflection	• formulate design guidelines	• reflect human cognition, reasoning processes and knowledge generation

Figure 2: *Short test "Am I a* Liaison*?" and list of the* Liaison *and VIS team tasks in each design process step.*

5.1. The *VisExpress*-project

The *VisExpress*-project is a design study with the goal to identify "interesting genes" in a vast amount of biological data. Clearly this is a high level aim with ill-defined tasks. Biologists requested to inspect genes with potential quality issues. The VIS team abstracted tasks & data and came to the conclusion that the problem is related to time series analysis with interactive filters (exclude genes without potential quality issues). This allows to efficiently handle quality issues to reduce the amount of data for the analysis. A standard visualization solution with small multiple line charts was sufficient for this problem and task abstraction (see Fig. 3 I). When the solution was deployed, the VIS team identified that the design was intuitive to the domain experts and that they could perform quality aware analysis, however, it seemed that the solution did not meet their expectation. Due to the *interdisciplinary communication issue* it was hard for the VIS team to understand their problems. Continuing the project with the first author (visualization Phd student with a major in bioinformatics), issues with the problem characterization became apparent. The first author identified that the VIS team did not capture the full complexity of the problem. Indeed the domain experts needed a quality aware data exploration system to detect patterns in a vast amount of data. Handling data quality issues was just one aspect of this problem.

This led to the idea of the *Liaison*. In the *VisExpress*-project our first author with a major in bioinformatics acted as an interdisciplinary *Liaison*. She was supported by a VIS team of three visualization colleagues, however, as a visualization PhD student she acted also as part of the VIS team. In this case the team has to be aware of role conflicts (see Sect. 6). The revised problem characterization led to the complex visual exploration system *VisExpress* (Fig. 3 II). Gene-fingerprint matrices replaced here the line charts, by representing all pair-wise time series ratios as well as their quality. Using the gene-fingerprints, a three levels architecture from overview (a) to data view (b) and detailed view (d) was designed to support data exploration and pattern detection. In the following, we will report further on lessons learned from *VisExpress*.

5.2. Tasks & Benefits

We describe tasks and benefits of a *Liaison*, and how this role can help to mitigate known pitfalls (PF) in the design process of problem-driven visualization projects [SMM12] (ordered by their occurrence in Fig. 2).

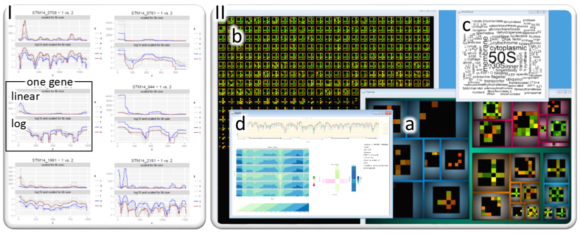

Figure 3: *Visualization approaches to visualize gene expression data. I) discarded prototype. II) final VisExpress-system.*

Capturing the problem complexity. Even though, methods like, e.g., contextual inquiries [BH97] work well, speaking the domain language and knowledge in the domain lead to a better problem understanding. Furthermore, also unspoken information can be captured and the danger to oversee things is minimized with a *Liaison*.

Capturing the mental model. To support insight generation, matching the mental model of the target user is one of the biggest challenges in visual design to allow the generation of insights [YKSJ08]. However, capturing the mental model is challenging and requires a deep domain understanding. For the *Liaison* it is easier to capture the mental model since she can build on her domain understanding and intensive discussions with domain experts in their language.

Faster and richer abstraction. A *Liaison* can avoid the pitfall to abstract too little (PF-19 in [SMM12]) or erroneous. Despite the pitfall of capturing only parts of the problem, we observed in the *VisExpress*-project that the VIS team tended to concentrate on an interesting visualization problem, thereby changing the focus which did not match the domain problem. Thus, a *Liaison* is needed to ensure that task and data abstractions still meet the domain problem.

Design validation. Another common pitfall is to consider a too small *Design Space* (PF-20). Here the independent VIS team ensures to span a broad *Design Space*. Without direct contact to domain experts the VIS team is independent and thus not biased by detailed domain issues that may hamper the development of ideas. Several persons are helpful here to avoid a related pitfall, which is to assume that the own latest visualization technique is a right match (PF-21). The *Liaison* canalizes the *Design Space* to balance design alternative against their fitting of the mental model.

Expressive and valuable evaluation. Evaluation issues are often artificial usage scenarios without real data & tasks (PF-24) and little expressive statements like *'The domain experts liked the tool.'* (PF-26). The reasons are a missing grounded problem understanding and a layperson's language. In contrast, the *Liaison* can speak the domain language and can act as a real analysis partner in a collaborative analysis with real data and tasks. Such an evaluation allows the *Liaison* to deeply discuss and assess findings during the study, leading to a clarification of tasks and usability issues. Feature requests can be captured between the lines in the domain language. In the *VisExpress*-project one remark was, e.g.: *'I would like to order the genes of one cluster in synteny to look for operons'*. The *Liaison* understood that the aim was to arrange genes sequentially to identify neighboring genes with the same pattern. Furthermore, we see high potential for a *Liaison* in Pair Analytics [AHKGF11] where the goal is to capture users reasoning processes during collaborative analysis.

6. Discussion and Limitations

Awareness of the problem complexity contradicts with a practical solution. A deep understanding of the problem domain regularly brings up new issues, which contradict with the current solution direction (PF-18 in [SMM12] - learning too much). This can make it harder for the *Liaison* to narrow down to a self-contained but still meaningful and essential visualization problem. Therefore, a consultation of the VIS team is important in the problem characterization phase.

A *Liaison* may suppress ideas. There is a danger that the *Liaison* might over-criticize ideas of VIS team members, especially if the *Liaison* person is also part of the VIS team. In brainstorming the *Liaison* can, e.g., easily use the domain knowledge and language for supporting own ideas. Therefore, we suggest to first discuss the ideas of the VIS team. In this step the *Liaison* contributes no own ideas, but objectively comments on the VIS team ideas. In the next step she contributes own ideas. All solutions are then presented, merged, refined or rejected in a discussion phase with the whole team.

Lost in translation. The *Liaison* reduces the direct communication between domain and visualization experts in a design study. Therefore, the success is highly dependent on the quality of the *Liaison*. Misinterpretations of domain problems, domain expert comments and study findings can lead to failed projects. To reduce these issues we recommend to discuss all interpretations with the domain experts to check their validity.

Alternative Approaches. Participatory design (PD) overcomes the interdisciplinary communication (IC) issue by mutual learning and involves the users in the design process. Business analysts (BA) are professional experts for analyzing workflows and requirements. It can be interpreted that BAs become a *Liaison* during the project, as their work necessitates knowledge of the technical feasibility as a software system and to gain domain knowledge. Learning and gaining knowledge make PD and BA approaches time intensive, but both lead to highly mature and tailored system for the stated domain problem. Visualization research has the additional focus on a research contribution. The *Liaison* role is suggested from this perspective. The cooperation with a VIS team ensures the visualization contribution, while the *Liaison* mediates between domain and VIS experts. Furthermore, the *Liaison* also allows to deal with time limitations of domain experts, which we often encounter in problem-driven research.

7. Conclusion

In this paper, we characterize the interdisciplinary communication (IC) issue – the source of many pitfalls in problem-driven research. To address this issue, we introduce the *Liaison* role and provide guidelines on the deployment in the design process. We describe the *Liaison* as one approach to address the IC issue and want to promote discussions and an exchange of ideas about alternative approaches, as well as follow up research in the visualization community.

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