AUTO-ID LABS

University of St.Gallen

**ETH** *zürich*

Auto-ID Labs ETH/HSG

# Year in Review

2017

# Content

Date of report: January 2017

Cover photo credit: ETH Zürich / Niklaus Salzmann

# Director's Note

Dear colleagues and friends,

On behalf of all our lab members, I'm delighted to share with you a few highlights of the research conducted at the Swiss Auto-ID Labs in the past year.

Our interdisciplinary team focused on the consumer side of the Internet of Things. While most consumers are continuously connected to the Internet, the retail industry is still at the beginning of its digital transformation. Today, we are only seeing the tip of the iceberg with consumers scanning barcodes in stores and thereby unknowingly get in touch with a GS1 system originally created to make businesses more efficient.

To be at the forefront of what will shape and influence the next five to ten years of GS1 standards, we conduct research in close collaboration with leading industry players and tech start-ups. We love to build things and evaluate new technologies in the wild. As you will see on the next few pages, our work includes a wide range of topics from mobile self-checkout, to product-related services, to reality-mining, to secure data sharing, to mobile health and nutritional literacy.
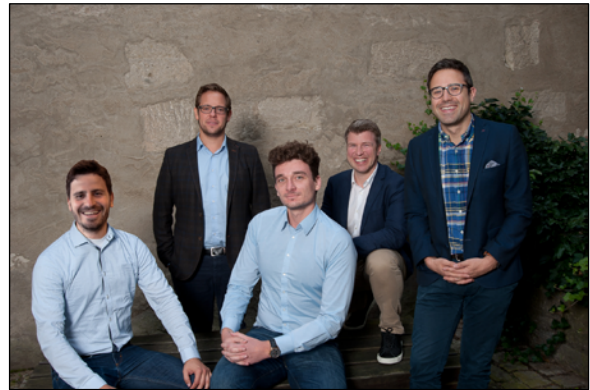
We believe that when ideas are shared, they become bigger. Therefore, we publish our results in leading academic conferences & journals, maintain close relations to the other Auto-ID Labs, attend GS1 events, support the labs' annual Internet of Things conference and engage in Europe's largest hackathon.

It is exciting to see the GS1 community's open spirit of innovation. Thank you for letting us be a part of this journey!

Alexander Ilic

Director Auto-ID Labs ETH/HSG

# Lab Members

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# Project Reports

IoT and Mobile in Physical Retail

# Novel Loyalty Schemes and Actionable Analytics

**Denis Vuckovac**

Ph.D. candidate and doctoral researcher

Consumers today are used to a high level of personalization in online retailing. Yet, most of the information systems in physical retailing are pre-dating the smartphone age and loyalty programs struggle with low user involvement. In addition to the low personalization, consumers still experience significant waiting times at the checkout leading to frustration and lost sales. We think that a "mobile-first" approach is the logic solution, fully leveraging the pervasiveness of smartphones of consumers thereby providing more convenience and a more personalized shopping experience with reasonable implementation effort and costs for retailers. More advantages for customers include reduced search costs and lower transaction times, while retailers can profit from more granular, individual customer data.

**Building Customer Loyalty through Mobile Technologies**

While Amazon finally opened its first checkout-less store to the public in January 2018, we are running a public pilot of our mobile self-checkout implementation, Scan&Go, at the main train station in Zurich since July 2016. Since then and with only little marketing, more than 100 users have made one or more purchase with the app. We have implemented our app for probably one of the most demanding settings in Europe: Switzerland has one of the highest share of commuters, mostly by train, and as a matter of fact convenience stores and kiosks at transit stations usually exhibit huge spikes in the morning and afternoon. It is during these periods of the day that consumers are most time constrained but queues are the longest. Thus, we have designed a mobile self-checkout application with the specific goal to minimize checkout times.



*Figure 1: Mobile Self-Checkout app Scan&Go:*
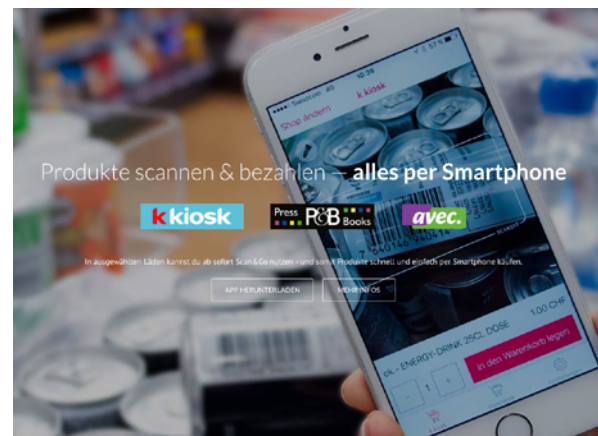
Further, we have shown that during peak times app users can purchase their coffee, soft drink or snack in about 30 seconds. Additionally, the immediate advantages for customers in form of time savings and added convenience resulted in additional purchases at the retailer. Thus, we were able to demonstrate how the mobile self-checkout solution ultimately increased the stated

purchase likelihood with the retailer, thereby building customer loyalty towards the retailer and the participating stores!
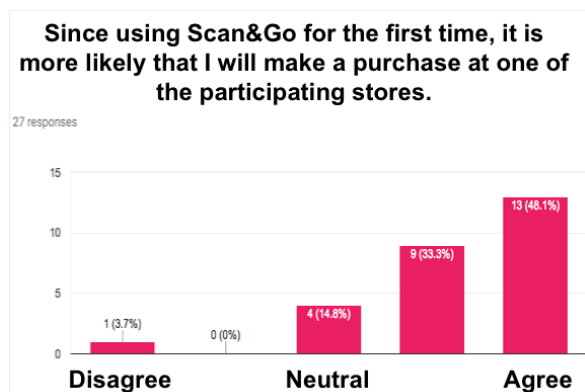


*Figure 2: Scan&Go final survey results on purchase likelihood after mobile self-checkout adoption*

## Measuring Customer Loyalty with Incomplete Information

While many retailers aim to foster customer loyalty, it is often unclear how loyalty is in fact measured or quantified. Ideally, retailers would aim for a "share of wallet" metric, yet in order to obtain such a statistic, knowledge of a customer's total spendings is required. However, retailers at best have knowledge of a customer's purchase history with themselves and are thus usually confronted with an incomplete information problem. In order to make such metrics more accessible to retailers, we have rebuilt, modified and extended a model from the quantitative marketing literature that allows retailers to calculate a share of wallet only based on the observations at hand. The model leverages regularities in customers' inter-purchase times to derive the true purchasing behavior of a customer and based on that derive the share of transactions conducted at the focal retailer. We have evaluated the model on simulation data (in which a random share of observations were deleted) and shown that it is successful in determining a customer's true model parameters (even the share of deleted observations) even in the absence of complete information. We ran our model on real transaction data from 10,000

customers at one big European retailer. Further, we were able to provide customer level summary statistics and segments of customers with similar purchasing patterns. With this model, the retailer is now able to quantify customer segments with low loyalty (as measured through share of wallet). Further, we have modified the model in order to provide category level share of wallet statistics and aim to further include promotional information into our model in order to quantify the impact of promotions on a customer's share of wallet or potential purchase acceleration.
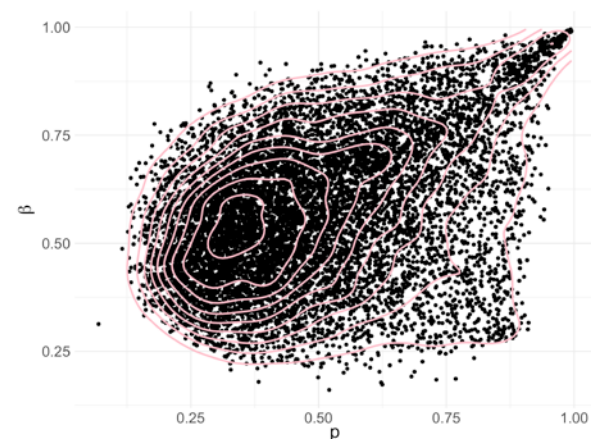


*Figure 3: Distribution of final model parameters p (a user's share of wallet) and $\beta$ (a user's true rate determining his inter-purchase times)*

## References

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[2]   Vuckovac, D., Hubert, L., Fritzen, P., Fuchs, K., Ilic, A., The need for public feedback for public information systems (published).

[3]   Vuckovac, D., Fuchs, K., Ilic, A., Fleisch, E., Building Customer Loyalty through a Mobile Self-Checkout Application (planned).

[4]   Wamsler, J., Vuckovac, D., Natter, M.., Ilic, A., Inferring True Inter-Purchase Times From Incomplete Information: A Model Comparison (submitted)
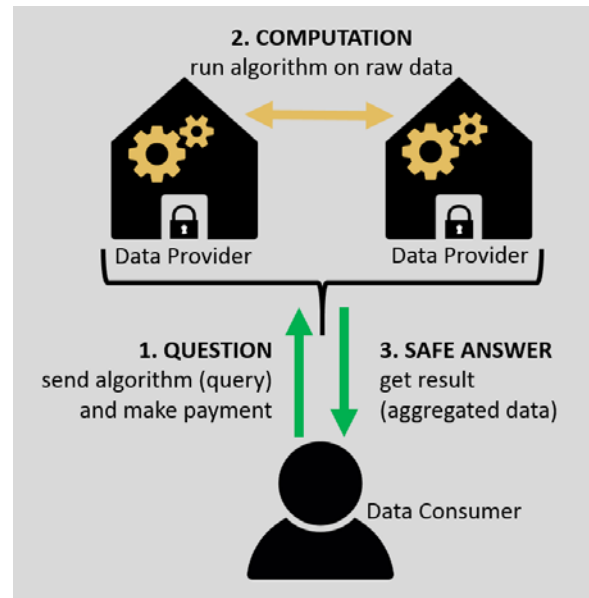
Unlock Sensitive Data with MIT's OPAL and Blockchain

# Secure Data Sharing

**Remo Frey**

Ph.D. candidate and doctoral researcher

## MIT's OPAL [1, 2]

Today there is the realization that for governments, societies and the industry to function there is the need to share information based on data. However, hand-in-hand with this need for data is also the corresponding need for privacy preservation for the subjects who may be represented in the data. There is a pressing need for access to data in order to enable new opportunities and new engagements. There is also the growing realization that data – both consumer data and business data – are increasingly distributed across both locations and owners. This raises both security and privacy problems, and also makes it uneconomical to query the data in a centralized fashion. New approaches to distributed data processing need to be adopted that address not only the multi-owner, distributed nature of data analysis, but also the problems of security and privacy. MIT's OPAL [Ref] aims to unlock the potential of data for public good in a privacy-conscientious, scalable, socially, and economically sustainable manner. The core idea is to ship code instead of data. It turns a very hard anonymization problem to an easier security problem. We believe that there is a huge potential because data exchange in a privacy-preserving and standardized way is essential for future business activities.



*Typical workflow of an OPAL scenario.*

## Prototype

Goal of the current research is to explore the potential of the new technology by developing a very first OPAL prototype in collaboration with MIT. The prototype is a mobile app and an OPAL test system. The use case is focusing on wildlife data because one of the OPAL founders have already a collaboration with a species conservation institution, namely San Diego Zoo Global. In fact, OPAL is applicable on any type of data in any commercial or non-commercial sector. We described the OPAL concept and the OPAL prototype in the context of wildlife data in two scientific articles [2, 3]. The planned field experiment could not be carried out because the prototype is not finished. One difficulty here is the completion of OPAL. The development of OPAL is done independently of us at MIT and takes longer than we expected. The completion of the prototype has been stopped. Nevertheless, we outline in the following the planned application using OPAL as underlying technology.

**Privacy-Preserving App for Wildlife Data [3]**

Humans have historically low engagement with the natural world. Global urbanization has led people to abandon wildlife-rich landscapes. The current lack of connectedness to nature is known as nature-deficit disorder. However, to encourage sustainable relationships between humans and other animals, technology to reconnect is urgently needed. The natural world is in a dire state; we are in the midst of a Sixth Mass Extinction. Here we propose that a novel information system, including a mobile app and privacy tools, could enable reconnection with the natural world. We propose the combination of real-time tracking data from wild animals and humans. Novel wildlife experiences, integrated into people's daily lives, may increase the connectedness to nature, which serves as a key factor for pro-environmental behavior. Further benefits are identified in education, philanthropy, health, and entertainment. Finally, we utilize the innovative privacy-preserving architecture OPAL to shield wildlife data from criminal intent like "cyber-poaching". The sensitive animal data like GPS coordinates remain secure behind the firewalls of the wildlife monitoring centers.



*Mock-up of the described wildlife app.*

**Disclosure of Personal Data [4]**

In light of digitalization, customers increasingly share private data through their online behaviors and actions. Yet, customers have become reluctant to share data due to privacy concerns. From a psychological perspective, a reduction of users' perceived risks should result in a higher willingness to share sensitive data. The development of blockchain-supported, multi-part computation thereby represents an interesting novel empirical context to study such willingness to disclose personal data, as such technologies involve a privacy-preserving approach that could not only technically solve privacy issues but also ought to address precisely the user's risk perception. Therefore, we conducted an online experiment with 420 participants to examine the willingness to disclose personal data dependent on different privacy protection mechanisms. A deception based experiment allowed to measure not only user intention, but also real user behavior. Surprisingly, our results demonstrate that participants shared similar amounts of personal data for blockchain-supported approaches and standard privacy policies. Even though an aversion to the blockchain system due to its novelty and potentially perceived complexity was not detected. Furthermore, we found that the willingness to share data increased significantly specifically for technically affine people when they were presented with the opportunity to monetize their data. We further discuss the effects of privacy awareness and whether prior knowledge of blockchain technology had a supporting effect for user acceptance.

**References**

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[2]  Frey, R.M., Hardjono, T., Smith, C., Erhardt, K., Pentland, A.S., Secure Sharing of Geospatial Wildlife Data, *4th International ACM SIGMOD Workshop on Managing and Mining Enriched Geo-Spatial Data (GeoRich)*, Chicago, IL, USA, 2017.

[3]  Frey, R.M., Miller, G.A., Ilic, A., Fleisch, E., Pentland, A.S., Wild Animals in Daily Life, *38th International Conference on Information Systems (ICIS)*, Seoul, South Korea, 2017.

[4]  Frey, R.M., Bühler, P., Gerdes, A., Hardjono, T., Fuchs, K., Ilic, A., The Effect of a Blockchain-Based, Privacy-Preserving System on Disclosure of Personal Data, *16th IEEE International Symposium on Network Computing and Applications (NCA)*, Cambridge, MA, USA, 2017.

Mobile Health
# Food Literacy and Healthy Nutrition

**Klaus Fuchs**
Ph.D. candidate and
doctoral researcher

**Limited Effectiveness of Nutritional Education**

Nutrition-related diseases are an alarming issue all over the world: In 2014 over 600 million adults and 42 million children were affected by obesity with growth rates of epidemic proportions [1]. Still, due to lack of financial resources, only a small part of society is reached through conventional measures such as education campaigns and nutritional coaching provided by physicians and dietitians.

New mobile health applications (mHealth) have potential to overcome these limitations. Further, recently introduced regulation is paving the way to support consumers in making healthy food choices through recently ratified legislation such as EU1169/2014 (Online declaration of nutritional ingredients) and EU GDPR/2018 (Data Privacy Regulation), allowing users to share their loyalty card logs with health applications. In order to research how product master and digital receipt data sets can be leveraged to mitigate nutrition related diseases, we work with strategic partners, incl. Swiss Federal Office of Public Health, Swiss Federal Food Safety and Veterinary Office, Swiss Society for Nutrition, Swiss health insurance and retail partners, GS1 Switzerland.

**FoodQuiz – Gamification for Nutritional Literacy**

"Swiss Foodquiz" was inspired by the world's most played educational trivia game Quizup, adapted to asking users to conduct a visual examination task requiring nutritional knowledge. The user task simulates choosing products at the supermarket shelve, as the user has to choose the one out of two similar, visually presented food products with the higher content of a relevant given nutrient, e.g. identifying the product with significantly lower amounts of salt compared to its substitutable alternative. With the approach, which has been published [2], it can be shown that the extension of serious game principles to nutritional education can increase nutritional literacy and overcome low acceptance rates among average, uninvolved and unhealthy users.

**SaltTracker – Digital Receipts & Diet Monitoring**

"Swiss SaltTracker" is a multi-stage project in which users log their diet through a validated Food Record Checklist. Further they share their loyalty card information including digital receipts of the past two years with the app. SaltTracker then computes a nutritional assessment for the user´s diet and purchases, suggesting product alternatives with lower sodium content. The research question behind is threefold: First, proving that digital Food Records correlate with current dietary monitoring practices, e.g. bio-sampling or paper-based recalls. Second, developing machine learning models that automatically deduce a valid classification of a user´s salt intake behavior from digital receipts to enable scalable dietary monitoring. Third, testing effectiveness of tailored interventions to convince users to reduce salt intake through personalized product recommendations.

**Barcode Poster – Allergy Compatibility Number**

Besides macronutrients, also allergens are included public product master databases and
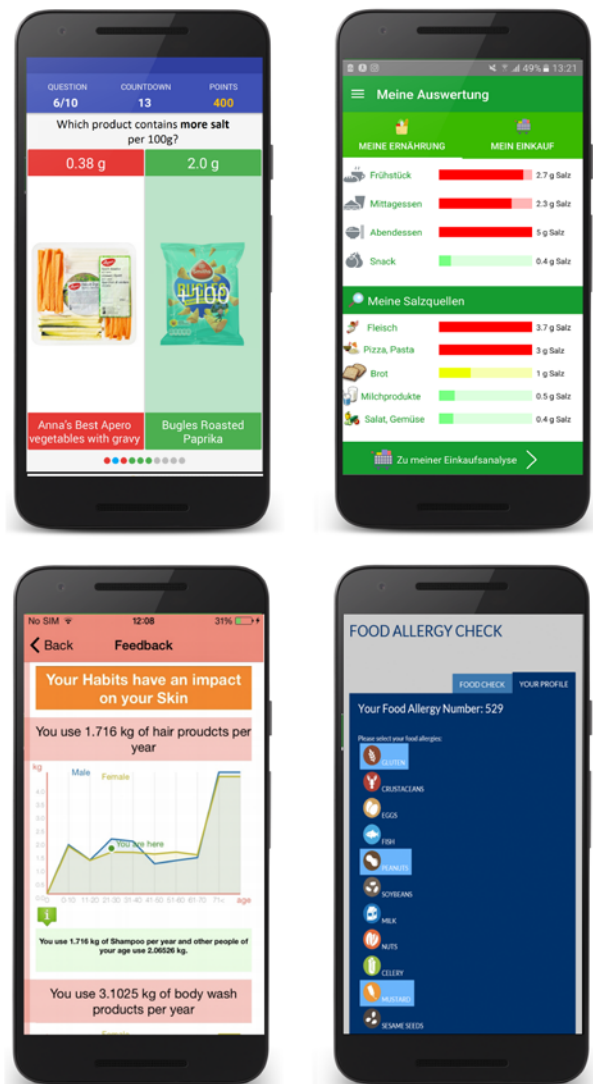
can be retrieved to build helpful applications for restaurant visitors and supermarket consumers. Therefore, we propose a new allergy identifying standard that works across countries and organizations such that any meal's or product's compatibility with a user's allergy profile can be computed instantly. The approach has been published and received a best poster award at the IOT Conference 2016 in Stuttgart [4].

**SkinProtect – Data for Exposure Assessment**

The EU1169-regulation only enforces online declaration of food items, but it is expected that also beauty and healthcare items are to be declared in public online databases. SkinProtect is a research app, that allows users to scan their household products and answer questions to their usage patterns, i.e. frequency and quantity. The app then calculates the exposure to certain incredients responsible for skin rashes.

**Conclusion and Outlook**

Our research exemplifies that automatic mHealth can indeed address the current health challenges by leveraging product master data and digital receipts, thereby achieving quantifiable gains in nutritional education, allowing for dietary monitoring and effective tailored interventions. Especially since the majority of app users are currently uninvolved in health, and therefore unlikely to be reached by other contemporary interventions, such mHealth offer promising potential of enrolling the previously uninvolved and uninterested users and to eventually change their attitude, involvement and behavior in regards to healthy behavior[3]. As democratizing knowledge and interventions are key elements of prevention, such scalable mHealth can become a vital part of effective healthy strategies.



*Research apps: 1) Foodquiz, 2) SaltTracker, 3) SkinProtect, 4) Food Allergy Check.*

**References**

1] M. H. Forouzanfar, L. Alexander, H. R. Anderson, et. al., "A systematic analysis for the Global Burden of Disease Study 2013," Lancet

[2] Fuchs, K., Huonder, V., Vuckovac, D., Ilic, A.. 2016. "Swiss FoodQuiz: Inducing Nutritional Knowledge via a Visual Learning Based Serious Game." In Proceedings of the 30th European Conference on Information Systems (ECIS), Istanbul, Turkey, 2016

[3] L. Hebden, A. Cook, H. P. Van Der Ploeg, and M. Allman-Farinelli, "Development of smartphone applications for nutrition and physical activity behavior change," J. Med. Internet Res., 2012.

[4] Frey, R., Ryder, B., Fuchs, K., and Ilic, A, "Universal Food Allergy Number", IOT 2016 Proceedings (Best Poster Award), Stuttgart, Germany, 2016

Behavioral Finance

# Financial Literacy & Credit Card Spending Control

**Johannes Huebner**

Ph.D. candidate and doctoral researcher

**Credit cards cause over-spending due to a lower pain of payment as compared to cash**

Consumers often refrain from using credit cards and other digital means of payment, because they fear they will lose control of their expenditure, and spend more than they would if they used cash, which has been confirmed by previous research studies. At the same time, consumers could benefit from using digital forms of payment for most of their purchases, since it would allow them to analyze and optimize their spending behavior. Partially due to this tendency for consumers to overspend, credit cards have a particularly bad reputation in continental Europe: Not only do they reduce the psychological pain of cash payments (empty wallet, ATM runs), but they also delay the customer's actual depletion of wealth to when the credit card bill is paid. In addition, individual purchase events are aggregated to one monthly credit card bill, all of which makes it challenging for consumers to intuitively learn from their credit card spending behavior.

**The Role of Exceptional Purchases [1]**

In addition to behavioral changes arising from the mere use of digital channels, behavioral economists have long argued that several mental biases can lead to sub-optimal decision-making with costly consequences. Research conducted by [2] highlights the importance of exceptional purchases in short-term financial decision making. They argue that consumers track expenses either explicitly, or implicitly using mental budgets. Research further shows that prior purchases in a particular category deplete the budget of said category, thus rendering the consumer more price-sensitive in future shopping events. Even for frequently occurring, ordinary expenses like groceries or transportation, consumers often face difficulties in accurately predicting and managing expenditures. However, for less frequently occurring, exceptional purchases like gifts or electronic gadgets, planning errors are more pronounced, arguably because people regard such exceptional purchases in a very isolated fashion (narrow choice bracketing), underestimate their frequency, cut themselves greater financial slack, and thus ultimately overspend

**Using mobile information systems to put consumers back in control over their payments**

Thanks to a collaboration with a large Swiss credit card issuer, we had the unique opportunity to conduct research with a sizeable group of consumers (N>1'000) using their credit cards in the real world whilst receiving feedback through our app over a period of three months [1]. We developed the mobile app Walter Finance, which displays users' credit card spendings, and provides weekly spending feedback. In the beginning of the study, each user was randomly assigned to one of four groups, each of which received different feedback. For example, one

group received feedback that particularly highlighted those transactions marked as "exceptional". Another group's feedback was designed to mimic the conventional mental accounting approach, where only "regular" transactions counted towards the weekly budget, and "exceptional" purchases (such as a new phone, or a gift for a spouse) would not affect the budget, allowing participants to cut themselves greater financial slack by marking transactions as exceptions. A control group simply received feedback on the total weekly spending, without further focus on either category. This research design allowed us to explore in a real-world setting if mobile-mediated feedback



interventions could change people's financial behavior.

From a pre-study with 95 employees of ETH Zurich as well as the credit card firm, we analyzed 822 completed weekly budgets and found promising evidence that our interventions are indeed effective in helping people reduce their credit card spending.

**Conclusion and Outlook**

Our research demonstrates how mobile information systems could be leveraged to nudge people to make better financial decisions. In this initial project, we focused on short-term financial decision-making (day-to-day spending), and helped people reduce their credit card spending. We believe that such digital interventions could provide a blueprint for helping people navigate the challenges arising from using digital payment channels, and guide user behavior in general. After a full analysis of the results with a representative sample of credit card users, we plan to kick-off a follow-up project that connects short-term financial-decisions with long-term ones such as retirement planning.

**References**

[1]    Huebner, J., Ilic, A: Too Sensitive to Share? Working with Consumers' Credit Card Transactions. In CHI 2018, Montréal, Canada (2018).

[2]    Sussman, A.B., Alter, A.L.: The exception is the rule: Underestimating and overspending on exceptional expenses. J. Consum. Res. 39, 800-814 (2012).

[3]    Huebner, J., Fuchs, K., Ilic, A: Preventing Over-Spending: Increasing Salience of Credit Card Payments through Smartphone Interventions. In Multikonferenz Wirtschaftsinformatik (2018).

*Mobile app:*
*i) goal attainment*
*feedback (top left),*
*ii) expense categorization*
*(top right)*
*iii) goal setting*
*(bottom left)*

Academia
# Our Teaching Track Record

Besides conducting research within our respective domains, the Auto-ID Labs also engage in teaching: At our universities ETH Zurich and HSG St. Gallen, we are supervising Bachelor and Master students during their thesis projects, . allows for fruitful collaborations between researchers and young talent. The Auto-ID Labs Switzerland are the leading lab with 56% of all thesis projects supervised at our chair.

**Thesis Projects as Ground for Innovation**

… innovative / API / etc.



**Why should the Auto-ID Labs and GS1 engage with students?**

University students represent the future generation of employees, managers and developers who will work, decide and build tomorrow's digital infrastructure. Therefore, engaging with students and student-run hackathons are ideal opportunities for the Auto-ID Labs and GS1 to collaborate with young talent, who are often not yet familiar with the world of GS1 standards and the opportunities they offer. In order to become more relevant in the digital space and spread awareness of standards, GS1 and its members should definitely keep an eye on upcoming hackathons.

… GS1 Cloud

## Overview of Thesis Projects at Auto-ID Labs Zurich:

| STUDENT NAME | YEAR | TOPIC |
|---|---|---|
| Lionel Buddensieg | 2018 | HSG, Master, Visualization of retirement preparedness to nudge long-term financial decision-making |
| Corina Hartmann | 2018 | Nutrition Literacy Review and International Empirical Study |
| Michael Zeltner | 2018 | AllergyScan- Product Barcode Scanner & Individual Allergy Feedback |
| Timothee Barratin | 2018 | BetterChoice- Product Barcode Scanner & Individual Nutrition Feedback |
| Colin Yao | 2018 | Augmented reality – Future-self nutrition avatar |
| Faina Kulak | 2018 | Loyalty card based nutrition analysis |
| Fabrizia Vollenweider | 2018 | Blockchain-based peer-to-peer data monetization platform |
| Dagem Kifle | 2018 | Nutrition mHealth app review – focus on gamification |
| Khawar Islam | 2018 | BetterChoice - Personalized healthier product recommender |
| Liat Ben-Haim | 2018 | BetterChoice - Personalized healthier product recommender |
| Nicole Erne | 2018 | Intention to use digital receipts for nutritional intake estimation |
| Vishal Moriani | 2018 | Identification of 16 network effects in the blockchain token universe |
| Daniel Linggi | 2018 | HSG |

| Stefan Kuzmiak | 2017 | ETH, Master, Payment Systems and underlying Business Models |
|---|---|---|
| Nico Klingler | 2017 | HSG |
| Laurent Hubert | 2017 | Design and evaluation of next-generation, beacon-powered self-checkout systems |
| Alexander Wolfensberger | 2017 | HSG, Bachelor, Nutritional mHealth Food Logging Mechanism Review |
| Daniel Meusburger | 2017 | ETH, Master, Future Self Nutrition Avatar |
| Priya Goel | 2017 | Detecting emerging business sectors using mobile application market analysis |
| Gaudenz Bösch | 2017 | HSG, Master, Modelling of derivatives on Ethereum Blockchain |
| Philipp Baumann | 2017 | HSG, Master, An Analysis of Fintech Startups' Valuation Drivers |
| Justus Spengler | 2017 | 1701 MA Privacy Calculus regarding mHealth on Purchasing Logs |
| Anja Muff | 2017 | |
| Henry Gallis | 2017 | HSG |
| Jonas Muff | 2017 | HSG, Bachelor, Blockchain-enabled Business Models |
| Veronica Schärer | 2017 | HSG, Master, Fintech Unbundling and Rebundling |
| Pascal Fritzen | 2016 | TU Munich - CDTM: Scan&Go App |
| Alexis Leibbrandt | 2016 | A smartphone controlled platform for scalable network of lights |
| Valerius Huonder | 2016 | Swiss FoodQuiz - Increase Nutritional Knowledge through a Serious Game |
| Philip Maximilian Stroisch | 2016 | Circle - Adoption of 3 types of IoT solutions as digital service end-points |
| Sven Brunner | 2016 | Swiss SaltTracker - Predicting Dietary Salt Intake from Loyalty Card Logs |
| Annabelle Bockwoldt | 2016 | Swiss SaltTracker - Estimating Salt Intake Behavior through mHealth |
| Alexander Gerdes | 2016 | Data Privacy & Open Innovation |
| Matthias Graf | 2016 | Kundenakzeptanz der 3D-Bodyscanning Technologie in der Bekleidungsbranche |
| Ioannis Michalopoulos | 2016 | ETH MTEC |
| Lauren Demaurex | 2016 | HSG |
| Michael Kalt | 2016 | HSG |
| Philipp Schullerus | 2016 | HSG |
| Christina Paschou | 2016 | ETH, Master, Investment Management Business Models |
| Nikolaos Kardasis | 2016 | ETH, Master, Blockchain-enabled Fintech Business Models |
| Verena Schmidt | 2016 | ETH, Master, Wealth Management Business Models |
| Charles Balachandran | 2015 | Skinprotect - Product Barcode Scanner & Individudal Toxicology Feedback |

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