

# Market Research Using a Virtual Test Store on Gaming Technology

Wolfgang Leister\*    Ingvar Tjøstheim†    Joachim Lous‡

## Abstract

We present the market research tool *ShelfAware* which implements a virtual test store of a grocery store using gaming technology available on PCs. The purpose of *ShelfAware* is to study user behavior including choice studies of grocery shoppers in a virtual environment, and hence give evidence on how customers would behave in a real store. Gaming technology is used for implementing a realistic looking replica of a real-world grocery store. Modelling aspects when designing or modifying virtual stores are addressed. We present results from usability studies of *ShelfAware*. Two issues are of special interest: (1) Are novice users capable of operating the tool, and (2) how does the behavior in a real store and the behavior in a virtual store compare. A real world user study with about 600 grocery shoppers of a selected grocery store was performed.

## 1 Introduction

Playing games has been a very human activity and has its function in learning, entertainment and leisure. With the advent of computer technology and its increased possibilities to design and implement games, more immersively than ever, an entire industry develops hardware, software and content for games. Games are available on standard PCs and game consoles, which are affordable to many.

The development of the computer game industry has developed fast, and even some years ago games which deliver realistic images in real-time have not been possible.

It is well known that kids, young adults and even some adults are spending much of time playing games [Ros03]. Even game-playing children realize that the driving forces in these immersive environments are the users' experience. Computer games are engaging because they provide increasingly realistic and lifelike 3D visual environments, thus driving the demand for home 3D entertainment. Immersion is one of the most important characteristics of computer games [Ros04, Rei03] in VR technologies [Ste92].

The gaming technology can also be used to build non-game applications. Examples are simulators, educational or training tools, cultural heritage applications such as virtual museums [TL05, TL06, Cha03, Cha04], and market research (MR) tools such as *ShelfAware*. *ShelfAware* is a non-game application for market research studies or consumer behaviour studies. In MR or consumer studies the aim is to collect information of behaviour, to predict how consumers behave, for instance what they choose when shopping. Personal interviews,

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\*Norsk Regnesentral, Postboks 114 Blindern, NO-0314 Oslo, Norway, email: Wolfgang.Leister@nr.no

†STHM, Temple University, Philadelphia, PA, email: ingvar@temple.edu

‡Viseno AS, Oslo, Norway, email: joachim@lous.org

paper based or electronic questionnaires and focus groups are examples of classic MR techniques.

This paper discusses the technical foundation of *ShelfAware* developed in a marketing research project presented at two industry conferences about market research [TSL05, TH05]. One of the most important features of the *ShelfAware* tool is its ability to replicate a shopping environment in a realistic and lifelike manner. Pictures from the physical store are used in to make (or replicate) the VR store. The *ShelfAware* tool can for instance be used to test new products, to study the content of shopping baskets, and “hot spots” in the store (Figure 1).

The paper is organised as follows: Section 2 presents how market analysis techniques and VR relate to each other. The technical implementation of *ShelfAware* is described in Section 3, while aspects of modelling the VR stores are described in Section 4. Key findings from the evaluation and validation of the tool are presented in Section 5 before concluding in Section 6.

## 2 Market Analysis and VR

In this kind of market analysis we study customer behaviour in a shop, e.g., with respect to placement of groceries, design of the shop, etc. Instead of rearranging a real store in order to perform analysis (rearranging a real store is rather costly and time consuming) it is preferable to model the shop in a VR application, and let the customers test the shop using a computer and immersive technologies.

In a market research context it is common to distinguish between stated preferences and revealed preferences [MC03]. Stated preference (SP) methods are ways of eliciting individual’s preferences for goods, courses of action or more general “alternatives” based on individuals preference opinions or “intentions” expressed in surveys or hypothetical, constructed markets, not real markets. Thus, this class of methods for preference elicitation differs from more traditional economic approaches based on individual’s actual behaviour, or revealed preferences (RP) primarily as SP methods typically do not ask individuals to commit resources in making choices.

A number of survey-techniques and methodologies are used to study purchase intents. However, an important disadvantage of purchase intents is its potentially limited predictive validity, as individual-level observed behaviour can differ from planned behaviour [Bem00, MSG97, VF02].

The VR-store *ShelfAware* can be classified as a SP method, where respondents make choices of complete products in a replicated shopping environment. The fact that the choices (products) are presented in a replicated shopping environment distinguishes our method from other choice experiment methods.

To create VR stores and computer based shopping environments for the purpose of doing market research is not a new idea. Several papers about VR-stores or VR-store concepts have been presented at market research conferences lately [TSL05]. Moreover, according to [BCG06] there is a growing evidence that computer simulated shopping experiments provide highly realistic buying behavior data [Kat99].

While games on a PC usually are optimised to give the player a most exciting experience and joy factor, our application is measured differently. Our goal is to implement a tool where the behaviour in the VR shop is as similar as possible to behaviour in a real shop. Computer graphics and immersion are used as a means to achieve this goal.

The use of first person shooter (FPS) game engines related to other applications than *shooting games* are presented previously, e.g., a proof of concept prototype of Queenscliff, Australia [GCP05].

### 3 ShelfAware

The *ShelfAware* package consists of an editor tool *ShopEdit* to design the VR shops, the simulator based gaming technology, and the path-tracker as an analysis tool beyond the statistical evaluations of items bought. The VR stores are presented on a PC in a gaming environment, and the users (customers) do not need gloves, spectacles or similar equipment. Using the game technology a 3-D experience and a feeling of immersion is created.



Figure 1: The VR store based on computer gaming technology. The contents of a shopping basket is shown. When looking at the product in the centre of the screen, the price tag and a larger image of the item appears.

The simulation software of *ShelfAware* is based on standard FPS engines. We used two different engines for the implementation in two different prototypes: the Quake 2 game engine from ID software, and the Torque game engine from GarageGames. In both cases some modifications had to be done in order to improve the graphics and adapt the “game rules” to the new application.

In the final implementation we use the Torque engine, since the source code could be licensed to an acceptable fee, and good editing tools were readily available. Although slightly dated, with some graphical improvements it delivers industrial-level performance in the areas we needed. In the commercial sector there are more advanced systems available that could be used, especially when it comes to lighting and other effects. However, from the perspective of MR these capabilities are not needed necessarily.

The geometry and textures of the VR stores are taken with a (non-professional) digital camera and used in order to replicate the VR stores. The model consists of photographic textures from the real shops wrapped onto quite simple geometric models. The result is highly dependent on the resolution of the texture images. Using standard digital cameras to take the pictures of the shelves in real shops we achieve suitably good realism. The capacity of graphics cards to handle high-resolution textures is moving fast and as a consequence a better realism can be achieved.

The user interface is modelled as a typical action game (look around with the mouse, move forward/backward with keys, using both hands at once), rather than the mouse-only point-and-click interface of typical desktop applications, which many other non-game desktop VR applications have chosen.

To be able to pick a product, the virtual customer must navigate close to the product before he or she can put the goods into the shopping basket by using mouse clicks.

This user interface offers a more immediate and direct control and it contributes significantly to the sense of immersion that such games produce. The gaming user interface offers better control to people without initial games experience. Since this interface paradigm is used in games with success we decided to apply it for the VR test store.

## 4 Modelling and Evaluation Tools

We wanted market-research practitioners who are not computer experts to be able to modify and author shop models and other contents with only light training. An important idea behind the project was that the current state of consumer hardware had made it possible to make high-quality VR applications *accessible* outside the traditional arenas of high-end industrial VR. Authoring of virtual shops should be possible for technical non-experts.

Therefore we strongly suggest creating custom modelling tools, specialised for exactly the small set of features needed for the application domain, and making them extremely simple to use. An added benefit of the custom tool *ShopEdit* is that its tailor-made nature with respect to the intended work-flow makes experts in MR more productive. Similar efforts for developing tools for other application areas can be found elsewhere, e.g., [GBHF05, FS06] for buildings.

The tool creation effort was focused on the part of the content pipeline that would be most

difficult for users to master with third-party tools: 3D modelling and texturing. While there are many excellent general purpose tools available, most of them are significantly more complex to learn.

## 4.1 Modeling Tools

Shops in *ShopEdit* are built from “modules”, which are simple geometric shapes (so far only plain boxes) representing a shelf rack, refrigerator, or other object. The surfaces of the modules are texture-mapped, many with photo-textures taken from real shop interiors. Some of the surfaces have associated “pickup points” from which the virtual shopper may examine and pick up a particular product. An example of the modules editing tool is shown in Figure 2.

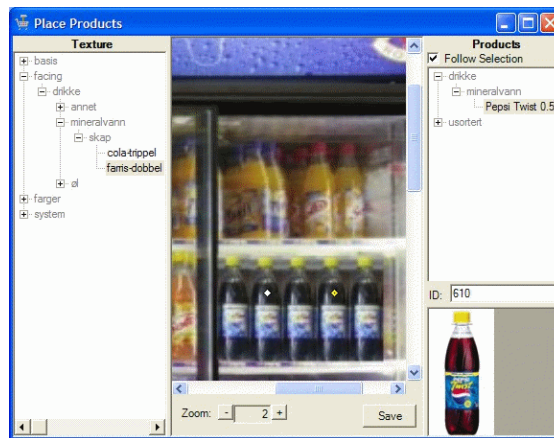


Figure 2: ShopEdit is used to organise images of shelves, and edit assets.

At the simplest level, editing a shop consists of arranging predefined modules from a library, as if they were literal building blocks. This is done in *ShopEdit* as shown in Figure 3, where modules may be placed, rotated, and stacked in the shop, all in a very direct WYSIWYG manner.

Modules themselves are created and managed in the module editor, as shown in Figure 4. Here one can create new modules, specify dimensions, apply textures from a texture library, and organise the library of modules, and alter existing modules.

The last component within *ShopEdit* is the product-placing tool. Here one can import and organise texture images, import and organise product close-up images, and place pickup points for a product on a texture. The pickup points automatically follow the texture and will appear in the simulator wherever the texture is used.

Extracting textures from photos before importing them into *ShopEdit* is done with third-party software. A specialised and integrated solution would be simpler and more efficient, but using the right image editing software it is at least relatively easy for anyone to learn.

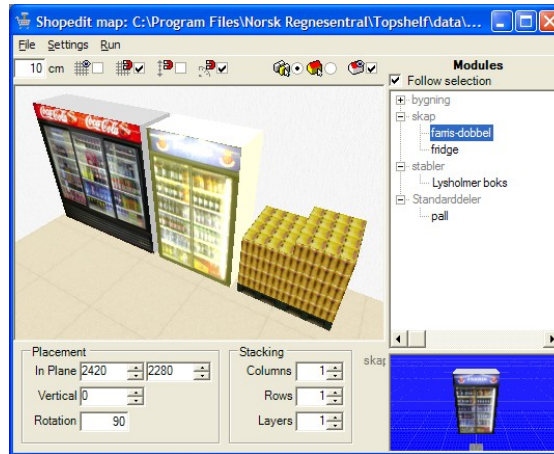


Figure 3: ShopEdit is used to organise shelves, and place them in the shop.

Photos of real shop interiors are taken using at least a good consumer-level digital camera. Individual faces of shelves etc. are then perspective-corrected, cropped and scaled to a suitable resolution (Figure 5).

Among the planned future enhancements to the tool are integrated texture extraction, and the ability to “build” composite textures from elementary product- and other images in a semi-automated and more user friendly way than general image-manipulation techniques.

## 4.2 Evaluation Tools

The focus of the current evaluation has been the comparison of the shopping baskets in the virtual shop and in the real shop, including interviews with the participants in the tests. The content of the shopping basket is available in the logs of the VR shop for each participant. *ShelfAware* offers interfaces to further custom tools: The movements of the customer in the VR store are logged during simulation, along with all purchases and products inspected. Pure sales figures etc. lend themselves to standard spreadsheets and statistics packages, but the logs contain a lot of other information that is best presented and analysed in a more visual manner. A snapshot from the path-tracker application is shown in Figure 6. The path-tracker can load several logs and visualise them in a map of the shop.

The illustration in Figure 6 shows the ‘basic path mode’, which is suitable for identifying where most of the traffic flows. Other display modes highlight time spent in different areas as a scalar field (identifying traffic bottlenecks and hot-spots of attention), movement vectors, mean gaze direction, and several others. Several components are planned to be integrated into *ShopEdit*, enabling visiting interesting places on the map, first-person playback of individual trips, and identifying attention hot-spots more precisely on individual surfaces based on 3D gaze direction.

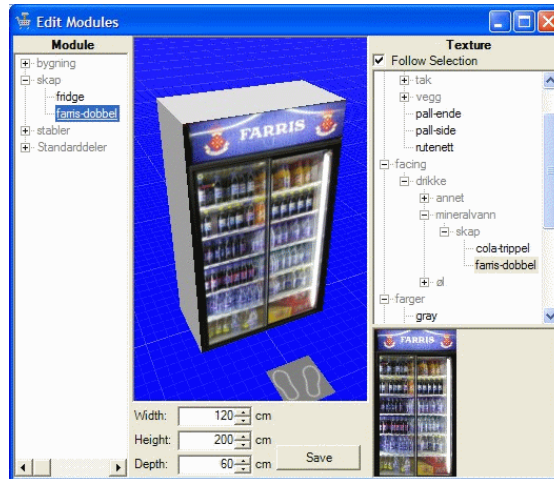


Figure 4: ShopEdit is used to model 3D representations of shelves.

## 5 Evaluation

In order to find out whether the customer behaviour using *ShelfAware* is related to the customer behaviour in a real grocery store we conducted evaluations in two grocery stores in Oslo. At the entrance of the shops we installed PCs with *ShelfAware* and asked customers to do a virtual shopping tour of what they intended to buy, and then do their shopping in the real grocery store. The respondents also answered a set of questionnaires regarding *ShelfAware* and their shopping trip. The log file of the VR store contained information of the choices in the VR store and the receipts contained information about the choices in the physical store. The VR store did not contain all products available in the physical store but all products of the category of the client in the project and some additional products, all in all 450 products.

Since the respondents were intercepted at the entrance of the stores, it was possible to invite them to first shop (e.g., choose products) in the VR-store before shopping in the grocery store. The respondents were given a demonstration by the interviewer, then he or she tried the program, and finally s/he were asked “to shop as you are going to do in the grocery store in a few minutes.”

In this section we concentrate on the feedback the users gave on the VR store, navigation, and questions such as whether it was easy or difficult to do the shopping task in the VR store, etc. Additional results from the evaluation can be found in papers intended for a market research audience [TSL05, TH05].

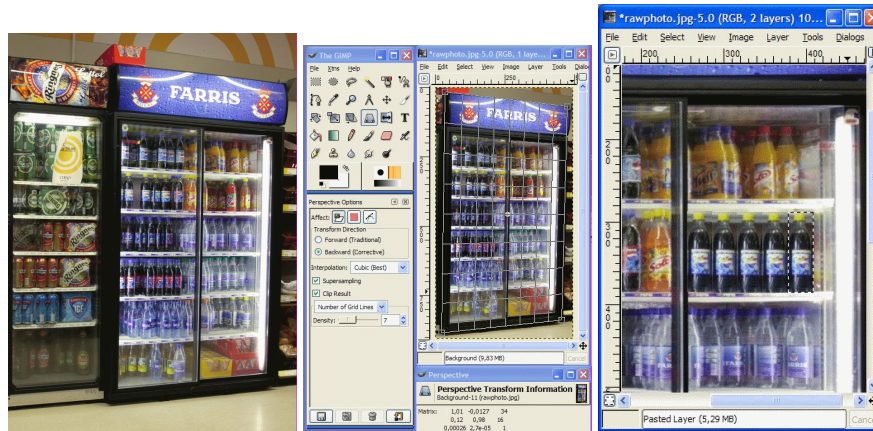


Figure 5: Preparation of the images. The photographs from a digital camera are normalised in the perspective, scaled, clipped, and edited using an imaging program.

## 5.1 Design of a Validation Study

Generally there are three alternatives to perform this kind of market research studies: (1) a lab-setting with PC's, (2) PC's installed outside or adjacent to the store, and (3) the use on a home computer. Even though grocery shopping is a very common shopping activity this does not mean that a respondent always is in a shopping mode. However, intercepting customers when they are in or just outside a store implies that the person already is in a shopping mode.

Customers were intercepted and invited as participants if he or she was going to buy at least one beverage products, the category of the client in the MR project. 603 customers participated in the study. All respondents were customers of the two stores and in a shopping situation/mode when participating in the study.

*ShelfAware* is intended for the average PC user and the evaluation contained questions regarding usability. An example is navigation and perceived ease of use. The respondents that do not use (or use very seldom) computer games (74%) answered that it was somewhat or very easy to navigate in the VR-store.

The outcome of whether the VR tool is suitable for MR purposes is not only dependent on the technical issues such as immersion and user interface, but also on the context in which the study is performed.

Besides being used close to a shop *ShelfAware* can also be used in a home-setting, where the user downloads and installs the tool in a PC. For certain MR studies this might be an alternative.



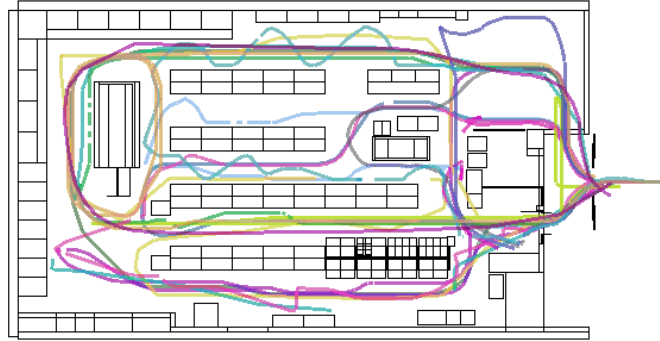


Figure 6: A path tracker tool is used to visualize the paths of the customers.

## 5.2 How significant is the validation?

When recruiting respondents the interviewers explained that the VR store resembles an Internet grocery store. Moreover, they were asked to give feedback, to give their opinion of the VR store and if it was easy or difficult to navigate in the VR store. Besides giving evidence on the technology used in the study, these questions also avoid a focus on the comparison of the behaviour (choices) between the VR setting and the real store. It is worth mentioning that some of the respondents commented that this would be a very nice Internet grocery store and that they enjoyed using the VR program.

Table 1 shows that 43% of the participants were less than 30 years old, which makes the average age lower than we would expect. The use of computer games. The majority, 67%, had not used computer games or had only played computer games a few times. As many as 69% answered that they are using computers daily, while the average in the Norwegian population is between 50% and 60%. Since the interviewers invited consumers to test a program on a computer, a higher percentage than the national average was expected.

The respondents were asked to test “a virtual store on a PC, something similar to an e-shop.” Since the respondents are customers of the replicated store most of them should therefore be able to recognise that they testing a replicated store. In Table 2 the answers of the respondents are presented, also showing the answers of the four categories of PC game users. Of the frequent users of computer games 84% answered daily and this numbered drops to 52% for those that had never tried a computer game. This is an expected result, it indicates that the frequent users of computer games are more skilled users than the non-users of computer games.

Approximately 80% answered that they recognised the store. However, it is interesting to notice that there seems to be no significant differences between the members of the four different segments. This is also the case for the feeling of presence with one exception. The VR store did create a feeling of presence for the majority (ca. 80%) and the figure only drops for the customers that have not used a computer game at all before. The purpose of the VR store (the market research tool) is to present a realistic shopping environment

Table 1: The profile of the respondents

Age		
18–19	7%	(42)
20–29	36%	(218)
30–39	23%	(139)
40–49	17%	(100)
50–59	12%	(71)
60+	6%	(33)
The use of PC		
Daily	69%	(417)
Weekly	19%	(194)
Monthly	4%	(26)
More seldom	7%	(43)
The use of Computer Games		
Once a week +	14%	(82)
Once a month +	20%	(118)
Only a few times	56%	(339)
Never used	11%	(64)
		N=603

to the respondent and to study consumer behaviour (of the respondents) in this virtual environment. Therefore it is important that a feeling of presence in the shop is created so that the shopper will get into a shopping mode.

There are significant differences between the user segments when it comes to navigation and finding products in the VR store; the frequent game users typically answer “very easy”, while the non/seldom users more often answer “somewhat easy.” Perceived easy of use is important, however the tools ability to predict real life choices and behaviour comprises more. After the participants had shopped in the VR store and the physical store they were asked about the task, the choices they made in the VR-store. The test participants did not have to pay for the goods in the VR shopping basket. Table 3 represents the results; the majority reported that they tried to do what they were asked to do. It should be commented that it is easy to answer “yes, I did what you asked me to do”.

The actual comparison of the content of the VR shopping basket vs. the real shopping basket of the customer is important for our study. For statistical testing shopping baskets from 603 customers is not a high number since these tests must focus on unique products. In order to test whether a market share of a product is similar to the market share of the physical store the same product must chosen a number of occurrences according to the statistical criteria. The statistical test was performed in 36 occurrences on this data. For 23 of the tests no significant difference between the VR store and the physical store were detected. However, significant differences were observed in 13 occurrences [TSL05, TH05]. For instance 11% answered that they did not do what we asked them to do when shopping in the VR store. Table 3 which might partly explain the deviation from our expectations.

Table 2: The feedback from the respondents.

	All	Use of Computer games			
		weekly+	monthly+	Occasionally	Never
Did you recognise the store?					
To a low extent	4% (23)	5% (4)	3% (4)	4% (12)	5% (3)
To a medium extent	14% (84)	9% (7)	19% (23)	12% (42)	19% (12)
To a high extent	82% (492)	87% (71)	77% (91)	83% (281)	77% (49)
First time in shop	1% (4)	0% (0)	0% (0)	1% (4)	0% (0)
Did you get the feeling of being in the store?					
Yes, I got a feeling of presence	80% (484)	85% (70)	78% (92)	83% (281)	64% (41)
In your opinion, how easy or difficult was it to move around in the VR-store?					
Very difficult	3% (19)	1% (1)	2% (2)	3% (11)	8% (5)
Somewhat difficult	18% (107)	5% (4)	11% (13)	21% (70)	31% (20)
Somewhat easy	37% (223)	24% (20)	35% (41)	40% (134)	44% (28)
Very easy	42% (254)	70% (57)	53% (62)	37% (124)	17% (11)
In your opinion, how easy or difficult was it to find the products you were looking for?					
Very difficult	3% (19)	1% (1)	3% (4)	4% (12)	3% (2)
Somewhat difficult	13% (78)	13% (11)	10% (12)	12% (42)	20% (13)
Somewhat easy	38% (226)	27% (22)	38% (45)	39% (132)	42% (27)
Very easy	46% (280)	59% (48)	48% (57)	45% (153)	34% (22)
	603	82	118	339	64

## 6 Concluding remark

The VR-store *ShelfAware* and the editing tools in *ShopEdit* are targeted for the use of ordinary users of PCs. The user of the VR-store tool is supposed to be able to navigate in the VR store, choose product and (best case) get an impression of being in the store, in order to get a result for the MR task that is as close as possible to the results from a real store. The use of gaming technology, especially the use of FPS games is our approach to create the tool that can be available at reasonable cost giving good results.

We performed an analysis of the usability and the immersiveness of our tool based on questionnaires and logged data from the experiments, in order to get feedback whether gaming technology is suitable for MR applications. While the VR tool did not always predict the market share precisely, the use of this tool predicted well most of the times when used in practice.

When performing the tests, 11% indicated that they did not take the shopping task on the computer very seriously. For the MR study the answers for those not taking the task in the VR store seriously should be considered invalid.

Technically several parts could be considered for improvement. The graphical layout, the complexity of models, the resolution of images and textures could be improved. However, the study shows that the users experience a sufficient degree of immersion. While we focused on hard- and software available in the consumer range, we have to find a tradeoff regarding the quality of the images, etc.

Table 3: The role as a test participant.

	All	Use of Computer games			
		weekly+	monthly+	Occasionally	Never
..., to what extent do you think that your choices were influenced by the fact that you did not have to pay for these products?					
I did not pay much attention since I did not have to pay for these goods	11% (67)	12% (10)	9% (11)	12% (41)	8% (5)
I tried to choose the goods I was going to buy in the store	83% (498)	78% (64)	88% (104)	80% (272)	91% (58)
Don't know	6% (38)	10% (8)	3% (3)	8% (26)	2% (1)
	603	82	118	339	64

We are currently working on improving the editing tools, both regarding the integration of tools into one user interface, and to extend the grocery store to other market segments. It is important that the editing tool is easy to use for the market analysts when experimenting with several layouts of shops. In our study we experienced that the use of gaming technology for MR purposes is promising.

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